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1918.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of about **1 000** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are FOUR dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

CAMP DEVENS AND ITS WATER SUPPLY.*

BY FRANK A. BARBOUR.

Camp Devens is one of sixteen similar cantonments constructed for the reception and training of men drafted under the conscription law of May 18, 1917. These camps — the locations of which were chosen by the commanding officers of the six army departments — ranged from Camp Devens to Camp Lewis, Washington, in the extreme northwest, and Camp Travis, Tex., in the extreme south, each having a tributary population of about 7 000 000 people.

The appropriation bill providing funds for construction did not become law until June 15, 1917, or eighty days before the date when the first quota of the draft were to arrive at the camps, but, under the Council of National Defence, the Committee on Emergency Construction, of six members (two of which, Messrs. F. L. Olmstead and M. C. Tuttle, were from Boston), had already made good progress in preparation for construction.

Brig.-Gen. I. W. Littell had been appointed officer in charge of cantonment construction, and Mr. F. M. Gumby (now Colonel), of Mr. Chas. T. Main's office, Boston, had been placed in charge of the engineering work of the Cantonment Division. A subcommittee of the Committee on Engineering Construction, composed

* This description of Camp Devens is based on an informal talk illustrated by lantern slides, given before the Association, March 13, 1918. Some references to the operation of the camp founded on data furnished by Major E. W. Briggs, officer in charge of Utilities, have been added. Discussion published in June, 1918, JOURNAL.

of Messrs. Leonard Metcalf, Geo. W. Fuller, and A. E. Phillips, had been active on the problems of preliminary planning, sanitation, and engineering relations to cantonment work.

Typical cantonment layouts were prepared at Washington, but it was necessary to adapt these to varying conditions at the different camp sites, to find water supplies, determine the method of sewage disposal, and plan railroad connections. With no men to spare in the Engineer or Quartermaster's Corps, a call was made for engineers to investigate the condition at each cantonment site. For the work at Ayer, a preliminary Board of Engineers, composed of Messrs. F. P. Stearns, H. J. Kellaway, and the writer, was appointed on May 25. On May 29 four survey parties, under Mr. George H. Wetherbee, were in the field, and between this date and June 9, a survey of 1 500 acres of rough, scrub-oak covered country was completed with sufficient accuracy to make possible the preliminary layout of the regimental units, the roads, the railroad connections, and the water and sewerage systems — the source of supply having been selected and the method and location of disposal works determined. Such results were only possible by working day and night, and acknowledgment should be made to the spirit displayed by the men engaged on the preliminary surveys.

On June 10, general plans and a report were submitted to the Cantonment Division at Washington and the results approved. Capt. Edward Canfield, Jr., U. S. Army (now Lieutenant-Colonel), had on the preceding day been appointed constructing quartermaster, and on June 14 arrived in Ayer. Fred T. Ley & Co., of Springfield, was selected as contractor by a special committee of the Committee on Emergency Construction, the contract being signed on June 19. Active construction began on June 25, or about seventy days before the date (September 4) set for the reception of conscripted men in camp — during which period it was proposed to do work involving an average expenditure of about $100 000 per day.

The construction quartermaster was the official representative of the Government, the disbursing official and the general manager of the work, and to him the engineers, the contractor, and the auditors were subordinate. No better man than Captain Canfield

CITY OR TOWN.	SERVICES.						Mains.	
	Owner of Water Works.	In Use.	Frozen.	Depth Laid in Feet.	Material.	Per Cent. Frozen.	Miles.	Length Frozen. Feet.
Ansonia, Conn.	P	1 164	160	4.5	GI	13.7	18.6	20; 30
Atlantic City, N. J.	M	7 375	.....	2–3	Tin lined; Iron; CI	....	110.0	400; 1 800
Auburn, Me.	M	2 532	6	5.5	GI; L; LI	0.2	34.0	200
Auburn, N. Y.	M	8 620	250	4.0	GI	2.9	70.0	0
Augusta, Me.	QM	2 400	2	5.5	LLI	0.08	47.4	0
Bangor, Me.	M	5 300	24	6.0	GI	0.5	56.0	0
Belfast, Me.	P	874	200	5.0–6.0	GI	23.0	.....	0
Belmont, Mass.	M	1 691	330	4.0	GI; CI; CLI	19.5	33.0	160; 100
Berlin, N. H.	P	1 480	150	4.0–6.0	GI	10.1	21.5	.....
Beverly, Mass.	M	4 700	500	5.0	GI	10.6	83.4	.....
Boston, Mass.	M	108 159	2 663	4.0–5.0	L	2.4	870.6	6720
Brewer, Me.	P	2 000	8	5.5–6.0	GI	0.4	19.0	0
Bridgeport, Conn.	P	23 000	250±	4.0	L; GI	0.9	300.0	100; 500
Bristol, Conn.	M	2 467	30	5.0	GI	1.2	47.2	24; 10
Brockton, Mass.	M	9 797	1 850	5.0	CLI; GI	18.9	126.5	0
Brookline, Mass.	M	5 800	10	5.5	CLI	0.2	98.5	0
Brunswick, Me.	M	1 000	25	5.0	GI	2.5	16.0	12″ gate
Burlington, Ia.	P	5 541	0	5.0	L; WI	....	53.7	0
Cambridge, Mass.	M	17 025	1 100	4.5	GI; LLI	6.4	135.0	50; 280
Claremont, N. H.	M	1 317	7	5–7	LLI	0.5	27.0	0
Cohasset, Mass.	P	704	13	4.0	GI	1.8	18.0	1 500
Chicopee, Mass.	M	4 000	1 100	4.0	L; LLI	27.5	71.5	1 800; 1 100
Danvers, Mass.	M	2 561	493	5.0	WI; CLI; GI	19.2	60.0	.....
Davenport, Ia.	P	9 900	10	5.5	L; GI	0.1	103.3	0
Dedham, Mass.	P	2 359	192	4.5	CI; WI	8.1	42.0	1 000; 100
Derby, Conn.	P	1 248	.....	4.0	GI	....	23.0	100; 200
Detroit, Mich.	M	143 898	.....	5–5.5	L; CI	.....	1 051.5	70; 220; 296
Devens, Camp	Gov.	974	.....	5.0	GI	....	20.3	.....
Dover, Mass.	M	1 987	41	5.5	CLI	2.1	25.0	0
Duluth, Minn.	M	12 419	147	7.5	L	1.2	180.0	.....
East Hartford, Conn.	M	2 200	625	4–5	GI	28.4	70.0	300; 1 500; 3 000
Edgartown, Mass.	P	372	50	3.5–4.0	CII	13.4	.....	.....
Fall River, Mass.	M	10 215	1 158	4.5–5.0	L	11.3	130.0	400; 925
Fairhaven, Mass.	P	1 223	75	4.5	LLI; TLL	6.1	21.8	1 000; 30
Falmouth, Mass.	M	1 400	100	4.0	GI	7.1	57.0	
Franklin, Mass.	M	1 180	300	5.0	CLI	25.4	30.0	.....
Franklin, N. H.	M	900	25	5.0	L; CLI	2.8	12.6	0
Glens Falls, N. Y.	M	3 648	75	4.5–8.0	GI	2.0	50.7	0
Gloversville, N. Y.	M	4 305	431	4.5–5.0	L	10.0	41.8	0
Greenfield, Mass.	M	2 696	40	5.5	GI	1.5	52.9	160; no
Hartford, Conn.	M	15 702	148	4 5 5.0	GI	0.9	303.6	0
Haverhill, Mass.	M	8 202	261	5.0	L	3.2	118.3	.....
Holyoke, Mass.	M	4 600	125	4–5.5	LLI; GI	2.7	97.1	0
Jewett City, Conn.	P	340	12	3.5–5.5	GI	3.5	9.0	100
Kitchener, Ont.	M	3 974	366	4.5–5.0	L	9.2	41.0	1 300; 300; 500
Lake Forest, Ill.	P	.....	6	5.0	GI	....	22.0	0
Lenox, Mass.	P	306	4	3.5	GI	1.3	27.0	0
Leominster, Mass.	M	3 073	110	4–6.0	CLI; CI	3.6	60.8	500
Lexington, Mass.	M	1 245	415	3–7	L; GI; LLI	33.3	38.0	.....
Littleton, Mass.	M	207	36	4.5	CLI; GI	17.4	8.4	.....
Manchester, N. H.	M	8 260	189	4–7	LLI	2.3	143.7	400
Middletown, Conn.	M	2 350	115	3.5–5.0	LLI; GI	4.9	.....	50; 50; 25
Milford, N. H.	M	640	8	5.0	.....	1.2	7.8	.....
Milton, Mass.	M	2 030	120	5.0	All kinds	5.9	53.0	150
Muscatine, Ia.	M	3 000	12	4.0	L; GI	0.4	42.0	0
Nantucket, Mass.	P	1 200	20	4.0	L; GI	1.7	12.0	6
Narragansett Pier, R. I.	P	863	92	5.0	L	10.6	18.9	.....
New London, Conn.	M	4 744	355	3.5–5.0	All kinds	7.5	71.2	450; 300
Norton, Mass.	P	280	65	4.5	CLI	23.2	13.0	0
Norwich, Conn.	M	4 000	250	4.5	L	6.2	62.0	.....
Newport, R. I.	P	6 942	50	4.0	L; CLI	0.7	87.5	221
New York, N. Y.	M	392 627	7 578	4.0	L; GI	1.9	3 157.0	2 200; 3 450; 500; 60
Northampton, Mass.	M	3 000	24	4.5–5.0	GI	0.8	77.0	200
Passaic, N. J.	P	9 160	209	4.0	LL; GI; L	2.3	84.0	0
Pawtucket, R. I.	M	12 668	700	4.7	WI; LL	5.5	202.0	7 000; 1 600; 5 600
Philadelphia, Pa.	M	350 000	2 000	3.0	L; GI	5.7	1 800.0	760; 3 000
Pittsfield, Mass.	M	6 115	282	5.0	GI	4.6	112.0	300; 175
Plymouth, Mass.	M	2 700	150	4.5–5.0	L	5.6	56.2	.....
Portland, Ore.	M	54 039	0	2.0	GI	....	745.0	0
Providence, R. I.	M	32 437	5 122	–5.0	L	15.8	436.9	.....
Putnam, Conn.	M	1 184	260	4.8	GI	21.9	18.0	1 000; 100
Reading, Mass.	M	1 731	250	4.5	CLI; LLI; GI	14.4	26.3	.....
Rochester, N. H.	M	1 660	65	4.5–5.0	GI	3.9	33.0	0
Rochester, N. Y.	M	50 000	375	4.5	L; GI	0.8	448.0	400
Rockville, Conn.	P	1 250	250	4.0	L; WI	20.0	24.0	1 000; 1 000; 250
St. Catharines, Ont.	M	5 247	352	5.0	L; WI	6.7	63.3	100
St. John, N. B.	M	7 158	81	6.0	L; GI	1.1	93.0	1 450
St. Paul, Minn.	M	41 480	1 190	7–8.0	L	2.9	429.6	600
Sanford, Me.	P	1 160	10	5.0	GI	0.9	17.0	2 340; 600
Saugus, Mass.	M	2 500	400	5.5	GI	16.0	40.0	60; 1 386
So. Paris, Me.	M	276	8	5–6	GI	2.9	8.0	0
Springfield, Mass.	M	15 611	800+	4.5–6.0	LL; GI	....	227.0	0
Stamford, Conn.	P	5 020	100±	3–4.0	WI	....	69.0	0
Sydney, N. S.	M	2 726	25	4.8	L	0.9	34.0	.....
Taunton, Mass.	M	5 930	450	5.0	CLI	7.6	96.9	2 000; 2 000
Troy, N. Y.	M	13 000	300+	5.0	L	....	111.0	.....
Waterloo, N. Y.	P	950	25	3–5	GI	2.6	15.0	0
Wallingford, Conn.	M	1 623	130	3–4	GI	8.0	35.7	600; 300; 100
Waltham, Mass.	M	4 332	600	5.0	CLI; GI	13.9	60.8	700; 200; 50
Wellesley, Mass.	M	1 622	150	5.8	CLI; GI	9.3	48.3	.....
Westfield, Mass.	M	3 000	100	4.5	GI	3.3	55.0	.....
Weymouth, Mass.	M	3 978	289	5	L; CLI; LLI	7.3	78.0	.....
Windsor, Conn.	M	525	36	3.5–4.5	GI	6.8	15.9	100
Winnipeg, Man.	M	34 440	6	7.5	L	....	274.0	600
Winthrop, Mass.	M	3 018	255	5.0	CLI; GI; L	8.5	34.0	.....
Woonsocket, R. I.	M	4 256	464	5.0	L	10.9	64.7	200; 200; 1 000; 3 000

	MAINS.				HYDRANTS.				METERS.								THAWIN		
									Inside.			Outside.					Method.		
	Sizes Frozen. Inches.	Dead Ends Frozen.	Depth Laid.	Material.	In Use.	Frozen.	Connection Frozen, Main Free.	Per Cent. Frozen.	In Use.	Frozen.	Per Cent. Frozen.	In Use.	Frozen.	Per Cent. Frozen.	Who Owns.	Who Pays for Repairs.	Mains.	Services.	Who Paid.
	6; 4	1; 1	2.5; 3.5; 5.0	CI	165	12	11	7.3	632	129	20.4	18	5	27.7	WC	O	E	HW; S; E	O
00	.....	1–8; 3–4	2–4	CI	1 011	50	45	5.0	25	0	0	7 300	1 000	13.7	M	M	S; F	S	M
	.....	1	5.0	CI	181	9	1	5.0	68	0	0	0	0	0	M	O	E	E	O
	.....	0	5.0	CI	731	4	2	0.6	900	100	11.1	37	2	5.4	M	M	E	E	O
	.....	0	5.5	CI	179	2	0	1.1	151	6	4.0	12	0	0	M	O	.....	HW	O
	.....	0	6.0	CI	326	0	0	0.0	125	4	3.2	0	.....	.....	M	M	.....	E	M
	.....	.....	5.5	WI	75	12	12	16.0	40	3	7.5	7	0	.....	WC	O	.....	HW	O
0	6; 2	3	4.5–5.0	2″ GI; CI	249	2	.....	0.8	1 600	135	8.4	100	10	10.0	M	O	E	E; HW	.....
.....	2	.....	4.0–6.0	GI; Wood; CI	81	59	2	72.8	325	55	16.9	4	0	.....	WC	O	E	E	O
	6; 4	17	5.0	CI; CLI	524	.....	All	large	1 583	250	15.8	.....	20	.....	M	O	E	E; HW	M
	4–6	30	3.5–4.5	CI	9 619	479	0	5.0	62 631	6 812	10.9	†	.....	.....	M	M	E; HW; S	E; HW; S	M
	.....	.....	6.0	CI; GI	69	0	.....	.....	25	2	0.8	4	0	.....	.....	.....	.....	E	.....
0	12–8–6	All	4.0	CI	1 663	98	40	5.9	2 000	150	7.5	1 000	80	8.0	WC	O	S	E; S	O
	6; 2	1	3.0–4.5	CI; GI	172	5	5	2.9	2 325	300	12.9	11	0	.....	M	O	E	E	O
	.....	.....	5.0	CI	1 184	2	0	0.2	9 649	1 230	12.7	167	15	9.0	M	O	.....	HW; E	.....
	.....	.....	4.5–5	CI	786	0	.....	.....	5 800	.....	.....	.....	0	.....	M	M	.....	HW	.....
e	.....	1	5.0	CI	130	0	.....	.....	1 100	250	22.7	65	6	9.2	M+C	O	.....	HW	M
	.....	.....	5.5	CI	533	0	.....	.....	200	.....	.....	.....	.....	.....	.....	.....	.....	Blow torch	O
0	6; 4	3	4.5	Steel; CI	1 205	.....	0	.....	‡6 100	487	8.0	.....	.....	.....	M	M	E; HW	E; HW	M
	.....	.....	5–6	CI; Cement	1 33	.....	.....	.....	927	43	4.7	0	.....	.....	M	M	.....	HW	M
	.....	2	4.0	CI	94	3	2	3.2	3	0	.....	20 out in winter			WC	WC	E	E	.....
00	6; 4	All	5.0	CI	379	20	0	5.3	3 300	800	24.2	25	0	.....	M	O	E	E	M
.....	2; 4; 6	All	4.5–5.0	CLI; CI	314	43	8	13.7	19	0	.....	2.4	0	.....	M	M	E	E; HW; S	*
	.....	.....	6.0	CI	1 004	6	0	0.6	7 400	199	2.7	6.25	3	0.5	WC	O	.....	Fire	O
00	6; 4	All	4.5	CLI; CI	192	10	2	5.2	2 182	303	13.8	87	17	19.5	WC	WC	E; HW	HW	WC
0	6; 4	All	4.5	CI	136	10	0	7.3	237	27	11.4	13	3	23.0	WC	WC	E	E	O
296	8; 6; 4	7	5–5.5	CI	Control of fire comm.				2	5 500	in all	.....	.....	.....	M	O	S	E	O
.....	0	.....	5.0	Wood; CI; WI	218	12	12	5.5	5	1	20.0	1	1	100	Gov.	Gov.	.....	E; HW	.....
	.....	.....	5.5	CI	227	6	0	2.6	1 598	78	4.9	0	.....	.....	O	O	.....	HW	*O
.....	6	7	7.0	CI	1 069	25	0	2.4	11 500	550	4.8	72	2	2.8	M	O	E	E	*O
3 000	6; 4; 2	1; 1	4; 4.5; 5.0	CI	175	45	10	25.8	40	3	7.5	2	0	.....	M	O	E	E	M
.....	.....	.....	3.5–4.0	CI	47	2	0	4.2	3	0	.....	0	.....	.....	.....	.....	.....	Natural	O
5	8; 6	400; 550	5.0	CI	1 573	1 155	44	73.4	10 264	2 100	20.5	0	.....	.....	C	O	HW	E	M
0	¾; 6	7	3–4.5	GI; CI	113	5	.....	4.4	1 218	148	12.2	5	2	40.0	C	O	S	E; HW; S	C½; O½
	3 lines less than 4″		4.0	CI	241	0	0	.....	6	0	.....	21	0	.....	M	M	E	E	.....
.....	.....	All	5.0	CLI; CI	147	1	0	0.7	1 180	140	11.9	10	6	60.0	M	O	.....	E; HW	O
	0	0	5.0	CI	121	0	.....	.....	900	125	13.9	0	0	.....	M	O	.....	E; S	.....
	0	.....	5–8	CI	343	43	43	12.5	43	2	4.6	17	0	.....	M	M	.....	E; HW	M
	.....	.....	4.5–6.0	CI	375	28	1	7.5	4 261	500	11.7	0	.....	.....	M	O	.....	E	O
0; no cover	8	.....	5.5	CI	356	2	1	0.6	271	10	3.7	19	1	5.0	M	O	.....	E; HW	O
	.....	.....	4.0 6.0	CI	1 819	83	25	4.5	15 364	920	5.9	.....	15	.....	M	O	.....	E; HW	M
.....	6; 4; 2; 1¼	All	5.0	CI	465	50	0	10.7	2 967	134	4.5	100	1	1.0	M	O	E	E	M
	.....	.....	4.5–5.0	CI	1 021	6	6	0.6	446	15	3.4	15	0	.....	M	O	.....	E; HW	M
	.....	2	3–5.0	CI	87	0	.....	.....	1	0	0	4	1	25	WC	O	HW	E; HW	O
500	.....	All	5.0	2″ GI; CI	344	6	2	1.1	3 679	210	5.7	4	0	.....	M	O	E	E	M; O
	.....	.....	5–6.0	CI	130	2	0	1.5	.....	10	.....	.....	4	.....	O	O	.....	E	O
	.....	.....	4.0	CI	50	0	.....	.....	341	6	1.8	40	1	2.5	WC	WC	.....	.....	M
	6	All	4–6	CI	409	29	6	7.1	2 477	180	7.3	104	0	.....	M	O	HW	HW	M
.....	6; 4	7	4.5	CI	220	1	1	0.5	1 139	100	8.8	106	25	23.6	M	M	E	E	M
.....	6	0	4.5	CI	52	0	0	.....	200	25	12.5	5	1	20.0	M	M	E	E	O
	.....	3	5.0	CI	997	30	3	3.0	6 766	72	1.1	0	0	.....	M	O	E; S	E; S; HW	M
5	3; 4; 6	1	3.5–6.0	CI	200	50	1	25.0	2 300	300	13.0	35	15	42.8	M	O	E	E	M
.....	4	1	4.5	CI	86	4	0	4.7	.....	25	.....	4	0	.....	M	O	.....	HW	O; M
	6	1	4.8	CI	439	8	7	1.8	1 982	150	7.6	48	1	2.0	M	M	E	E; HW	M
	.....	.....	6.0	CI	448	0	.....	.....	2 000	100	5.0	25	0	.....	M	.....	.....	.....	O
.....	1¼	0	4.0	CI; GI	83	4	2	5.0	2	1	50.0	3	2	66.7	WC	.....	HW	HW; F	O; WC
	4; 6	1; 6	5.0	CI	179	3	0	1.7	.....	0	.....	.....	.....	.....	WC	WC	E	E	WC½; O½
0	6; 4	6	3.0–6.0	CI	390	4	.....	1.0	3 073	171	5.7	492	390	79.5	M	M	E; HW	E; HW; F	M
	.....	.....	5.0	GI; CI	66	0	.....	.....	8	2	25.0	0	0	.....	WC	WC	.....	E; HW	O; WC
.....	8; 6; 4	5	4.5–5.0	CI	509	8	8	1.6	1 120	250	22.4	17	0	.....	M	O	E; HW	E; HW	M
	8	1	4.0	CI; LLI; Sheet Iron	323	12	11	3.7	124	10	8.1	16	0	.....	C	C	Pipe split, not thawed.	S	WC
00; 600	4; 6; 8; 12	30	4.0	CI	49 467	4 576	.....	9.2	102 839	13 650	1.3	1 951	351	17.9	C	O	E; S	E; S	O
	.....	1	4.5–5.0	CI	533	25	6	4.7	147	5	3.4	8	0	.....	M	O	S	HW; S	M
	.....	.....	4.0	CLI; CI	725	5	5	0.7	6 259	656	10.5	138	15	10.9	WC	O	.....	E; S	O; WC
5 600	.....	48; 9 700	4.5	CI	1 245	82	75	6.6	11 520	3 000	26.0	0	.....	.....	M	O	E; HW; S	E; HW; S	M
0	.....	All	3.5	CI	18 000	300	.....	1.7	85 000	1 500	1.8	0	.....	.....	C	O	.....	E	O
	.....	0	5.6	CI	590	27	27	4.6	597	10	1.7	29	5	17.2	M	O	E	E	O
.....	.....	.....	4.5	CLI	226	Fire dept. controls			494	18	3.6	30	7	23.3	M	M	.....	E; HW	M
	.....	.....	4.0	CI; GI	5 166	0	0	.....	.....	.....	.....	17 152	0	0	M	.....	.....	.....	.....
.....	6–12	Few	4.7–6.3	CI	2 440	.....	.....	.....	No record			.....	.....	.....	C	O	S	E; S	O; M
0	6; 4	All	5.0	CI	95	1	.....	.....	100	5	5.0	7	0	.....	M	M	E	E	O; M
.....	6	All	4.5	CI	201	.....	.....	.....	1 456	217	14.9	207	33	15.9	M	M	E	E; HW	.....
	0	.....	4–6.0	GI; CI	180	4	1	2.2	1 201	38	3.2	0	.....	.....	MC	O	.....	HW	O; M
	6	1	4.5	CI	5 670	.....	4	.....	49 000	1 400	2.9	450	26	5.8	C	C	E; S	E; S	O
250	6; 4; 2	6	4.0+	WI; CI	170	6	4	3.5	445	50	11.2	1	0	.....	WC	O	E	E; HW; S	O
	4	1	5.0	CI	414	6	0	1.4	220	18	8.2	37	2	5.4	MO	O	.....	E	.....
	4–12	7	4–7.0	CI	518	15	10	2.9	172	7	4.1	156	1	0.6	M	M	S	E; HW	M
	6	All	7.5	CI	3 803	750	0	19.7	36 309	541	1.5	0	.....	.....	M	O	S	E	M; O
0	10; 6	3	5.0	CI	71	0	.....	.....	1 100	35	3.2	2	0	.....	WC	O	E; HW	HW	WC; O
	4; 6	5	5.0–6.0	CLI; CI	340	20	2	5.9	700	50	7.1	0	.....	.....	C	O	E	E; HW	M
	.....	0	5–6.0	CI	38	3	3	7.9	7	0	0	0	0	0	M	M	E	E	M
	0	0	5.5	CI	1 984	25±	2	.....	14 925	913	6.1	417	74	17.8	C	O	.....	E; HW	M
	0	0	4.0	CI	324	0	0	.....	3 500	450	12.9	150	5	3.3	WC	O	S	S	.....
.....	4–24	0	4–6.0	CI	175	3	3	1.7	30	0	.....	5	0	.....	M	.....	E	E	M
0	6; 8	4	4.8	CI	1 085	0	6	0	3 653	490	13.4	51	7	13.7	C	M	E	E; HW	M
.....	.....	1	5.0	CI	1 134	100+	39	.....	296	14	4.7	0	.....	.....	C	O	E	E; WH; S	O
	.....	.....	4–6.0	CI	76	4	4	5.6	250	5	2.0	6	0	.....	WC	O	.....	E; S	O; WC
00	2; 4; 6	5	4–4.5	WI; CI	140	1	1	0.7	308	25	8.3	10	0	.....	M	.....	E	E; HW	½ O; ½
0	10; 6; 4	All–2	5.0	CI	512	6	2	1.2	2 700	390	14.4	10	10	100.0	M	O	E; S	E; HW; S	.....
.....	6	3	5.8	CI	370	6	3	1.6	1 572	41	2.6	50	0	.....	M	O	E	E; HW	O; M
.....	6; 2	2	5.0	CI	308	2	0	0.6	72	2	2.8	5	0	.....	M	M	E	E	M
.....	6; 4; 2	17	5.0	WI; CI	460	26	26	5.6	1 855	238	12.8	145	79	54.5	M	O	E	E; HW	O
	2	0	3.5	WI; CI	47	5	0	10.6	45	4	8.9	5	0	.....	M	O	E	E; HW	O ½; M
	6	0	7.5–8.0	CI	2 363	633	0	26.7	30 708	896	2.9	0	0	.....	M	M	S	S	M
	.....	1	5.0	CI	300	2	.....	0.7	2 843	123	4.3	175	4	2.3	M	O	E	E; S; HW	O; M
3 000	12; 8; 6; 4	7	3.5–5.5	CI	746	80	60	10.7	4 062	1 090	26.8	0	0	.....	M	O	S; E	E	O ½; M

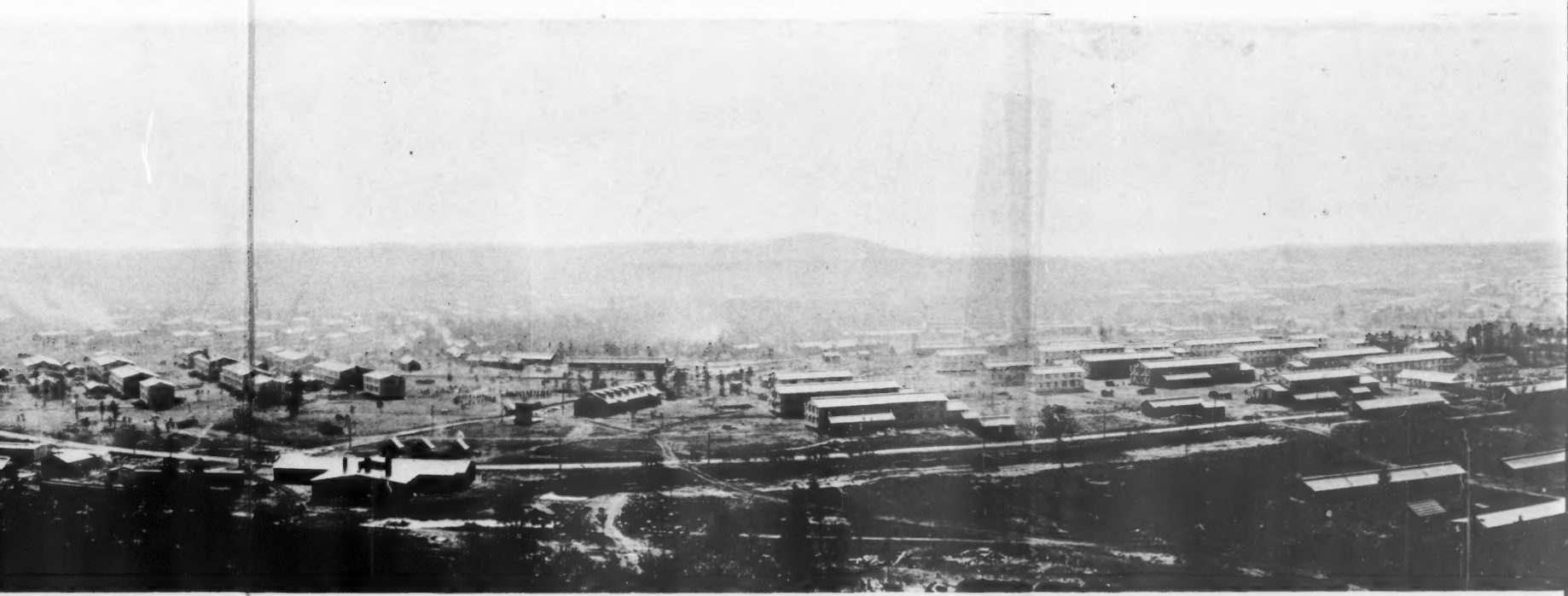
M = Municipality. GI = Galvanized iron; LLI = Lead-lined iron; CI = Cast iron; CLI = Cement-lined iron; WI = Wrought iron; TLL = Tin-lined lead; L = Lead. WC = Water company. E = Electricit

METERS.					THAWING.							TEMPERATURE.																
Outside.					Method.			Cost of Service.				Air.																
												Nov.			Dec.			Jan.			Feb.			Mar.			
In Use.	Frozen.	Per Cent. Frozen.	Who Owns.	Who Pays for Repairs.	Mains.	Services.	Who Paid.	Electricity.	Steam.	Hot Water.	Fire	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	
18	5	27.7	WC	O	E	HW; S; E	O	20.0	5.0	5.0	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
7 300	1 000	13.7	M	M	S; F	S	M	No separate costs				50	34	42	36	22	29	31	18	24	39	24	32	49	33	41	S
0	0	0	M	O	E	E	O	.....				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
37	2	5.4	M	M	E	E	O	15.0	Flat	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
12	0	0	M	O	.....	HW	O	.....		.....	.....	..	..	..	..	..	..	..	..	..	56	–38	10	..	..	..	
0	.....	.....	M	M	.....	E	M	.....		.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
7	0	.....	WC	O	.....	HW	O	.....		.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
100	10	10.0	M	O	E	E; HW	.....	3.50	.....	2.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
4	0	.....	WC	O	E	E	O	4.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	20	.....	M	O	E	E; HW	M	.....	.....	.....	.....	..	..	37	..	..	25	..	..	19	..	..	25	..	..	24	
†	.....	.....	M	M	E; HW; S	E; HW; S	M	*15.99	17.70	6.32	11.16	65	13	39	48	–14	24	54	–3	21	57	–10	27	69	11	37	
4	0	.....	.....	.....	.....	E	.....	6.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1 000	80	8.0	WC	O	S	E; S	O	15 ±	20.0	.....	.....	..	..	..	..	..	..	..	..	..	..	–21	..	..	..	..	
11	0	.....	M	O	E	E	O	.....		.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
167	15	9.0	M	O	.....	HW; E	.....	7.0	.....	3.0	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	0	.....	M	M	.....	HW	.....	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
65	6	9.2	M+C	O	.....	HW	M	.....	.....	3.0	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	.....	.....	.....	.....	.....	Blow torch	O	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	.....	.....	M	M	E; HW	E; HW	M	5.33	.....	2.00	.....	57	11	..	42	–12	..	46	–3	..	53	–3	..	63	–8	..	S
0	.....	.....	M	M	.....	HW	M	.....	.....	.....	.....	..	..	..	34	–30	..	30	–33	..	47	–20	..	41	–5	..	
20 out in winter			WC	WC	E	E	.....	5.50	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
25	0	.....	M	O	E	E	M	3.00; 10.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
2.4	0	.....	M	M	E	E; HW; S	*	.....	.....	.....	.....	..	..	..	38	–12	..	39	0	..	44	–13	..	46	6	..	
6.25	3	0.5	WC	O	.....	Fire	O	.....	.....	.....	.....	72	18	42	50	–11	18	38	–18	10	63	–14	27	76	14	45	
.87	17	19.5	WC	WC	E; HW	HW	WC	9.04	.....	8.12	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
13	3	23.0	WC	WC	E	E	O	.....	.....	.....	.....	49	27	37	31	14	18	29	8	14	37	13	21	..	..	..	
.....	.....	.....	M	O	S	E	O	10.00	.....	.....	.....	45	32	38	28	16	22	20	7	13	34	15	25	49	30	40	
1	1	100	Gov.	Gov.	.....	E; HW	.....	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	54	–2	31	57	6	36	
0	.....	.....	O	O	.....	HW	*O	.....	.....	5c p ft.	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
72	2	2.8	M	O	E	E	*O	8.14	.....	.....	.....	41	28	34	14	–5	4	9	–7	1	20	2	11	41	22	31	
2	0	.....	M	O	E	E	M	4.25	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	.....	.....	.....	Natural	O	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	C	O	HW	E	M	5.33	.....	.....	.....	..	..	..	37	27	32	25	14	19	32	18	25	41	29	35	
5	2	40.0	C	O	S	E; HW; S	C½; O½	8.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
21	0	.....	M	M	E	E	.....	est. 5.0	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
10	6	60.0	M	O	.....	E; HW	O	5.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	0	.....	M	O	.....	E; S	.....	10.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
17	0	.....	M	M	.....	E; HW	M	10–15	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S
0	.....	.....	M	O	.....	E	O	5.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
19	1	5.0	M	O	.....	E; HW	O	6.00	.....	4.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	15	.....	M	O	.....	E; HW	M	11.75	.....	11.20	.....	64	13	37	43	–18	20	51	–8	17	56	–11	25	69	11	38	
100	1	1.0	M	O	E	E	M	11.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S
15	0	.....	M	O	.....	E; HW	M	5.40	.....	3.60	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
4	1	25	WC	O	HW	E; HW	O	12.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
4	0	.....	M	O	E	E	M; O	2.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
.....	4	.....	O	O	.....	E	O	20.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
40	1	2.5	WC	WC	.....	.....	M	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
104	0	.....	M	O	HW	HW	M	.....	.....	5.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
106	25	23.6	M	M	E	E	M	4.87	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
5	1	20.0	M	M	E	E	O	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	0	.....	M	O	E; S	E; S; HW	M	7.36	9.41	5.50	.....	57	2	35	40	–20	18	44	–20	16	47	–21	21	67	3	37	
35	15	42.8	M	O	E	E	M	*6.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
4	0	.....	M	O	.....	HW	O; M	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
48	1	2.0	M	M	E	E; HW	M	12.46	.....	2.00	.....	45	28	37	26	18	24	26	11	19	37	17	28	45	24	36	
25	0	.....	M	.....	.....	.....	O	.....	.....	.....	.....	50	34	42	24	11	18	18	2	10	36	17	26	55	33	44	
3	2	66.7	WC	.....	HW	HW; F	O; WC	.....	.....	.....	.....	46	14	35	42	4	23	40	2	21	42	–10	26	40	16	32	
.....	.....	.....	WC	WC	E	E	WC½; O½	5.00	.....	.....	.....	63	9	38	50	4	28	48	–12	18	56	–13	23	65	8	35	
492	390	79.5	M	M	E; HW	E; HW; F	M	5.00	.....	17.00	10.69	46	14	34	42	0	23	44	4	18	46	–9	25	44	17	34	
0	0	.....	WC	WC	.....	E; HW	O; WC	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
17	0	.....	M	O	E; HW	E; HW	M	Arc 3.50				..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
16	0	.....	C	C	Pipe split, not thawed.	S	WC																				
951	351	17.9	C	O	E; S	E; S	O	Data not available varied from $10–$30				63	18	41	46	–13	25	53	–4	21	56	–7	29	74	16	41	
8	0	.....	M	O	S	HW; S	M	10.00	Average	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
138	15	10.9	WC	O	.....	E; S	O; WC	10.11	7.63	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	M	O	E; HW; S	E; HW; S	M	10.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	C	O	.....	E	O	20.00	.....	.....	.....	65	23	43	50	–4	28	57	2	24	60	–2	33	78	18	44	
29	5	17.2	M	O	E	E	O	7.00	.....	.....	.....	43	25	34	25	8	16	19	4	11	29	9	19	43	23	33	
30	7	23.3	M	M	.....	E; HW	M	10.00	.....	.....	.....	47	31	..	33	22	..	34	15	..	37	19	..	47	29	..	
152	0	0	M	.....	.....	.....	.....	.....	.....	.....	.....	66	34	57	65	34	48	59	24	45	59	22	42	76	31	47	
.....	.....	.....	C	O	S	E; S	O; M	3.11	.....	.....	.....	63	16	40	50	–10	27	54	1	24	58	–8	29	70	13	40	
7	0	.....	M	M	E	E	O; M	5.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
207	33	15.9	M	M	E	E; HW	.....	Average	4.50	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	MC	O	.....	HW	O; M	1.00	.....	.....	.....	62	0	29	42	–26	14	44	–20	11	58	–20	19	66	–4	27	
450	26	5.8	C	C	E; S	E; S	O	Average	7.50	.....	.....	54	11	35	45	–8	20	40	–2	15	55	–11	24	74	5	36	
1	0	.....	WC	O	E	E; HW; S	O	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
37	2	5.4	MO	O	.....	E	.....	2.50	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
156	1	0.6	M	M	S	E; HW	M	2.50; 5.00	.....	3.00; 5.00	.....	36	27	..	23	12	..	19	7	..	28	15	..	30	16	..	
0	.....	.....	M	O	S	E	M; O	2.83	.....	.....	.....	45	31	38	18	2	10	11	–4	4	28	7	17	48	29	38	
2	0	.....	WC	O	E; HW	HW	WC; O	6.50	.....	3.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	.....	.....	C	O	E	E; HW	M	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	0	0	M	M	E	E	M	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
417	74	17.8	C	O	.....	E; HW	M	Average	6.50		.....	56	–1	28	35	–26	11	31	–26	7	44	–26	22	68	–2	33	
150	5	3.3	WC	O	S	S	.....	Average	75.00		.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
5	0	.....	M	.....	E	E	M	12.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
51	7	13.7	C	M	E	E; HW	M	5.50	.....	4.80	.....	64	3	35	49	–15	23	49	–13	18	55	–21	24	66	–2	35	
0	.....	.....	C	O	E	E; WH; S	O	15.00 + labor	.....	.....	.....	57	10	35	42	–19	17	47	–11	14	52	–15	22	69	8	35	
6	0	.....	WC	O	.....	E; S	O; WC	10.00	16.50	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
10	0	.....	M	.....	E	E; HW	½ O; ½ M	6.00	.....	4.50	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
10	10	100.0	M	O	E; S	E; HW; S	.....	6.00	N; G	2.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
50	0	.....	M	O	E	E; HW	O; M	2.52	.....	2.67	.....	Same as Boston															
5	0	.....	M	M	E	E	M	5.00	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
345	79	54.5	M	O	E	E; HW	O	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
5	0	.....	M	O	E	E; HW	O ⅓; M ⅔	18.09	.....	20.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	0	.....	M	M	S	S	M	.....	.....	.....	.....	70 above to 35 below															
475	4	2.3	M	O	E	E; S; HW	O; M	10.00	14.00	14.00	.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
0	0	.....	M	O	S; E	E	O ½; M ½	5.00	.....	.....	.....	..	..	..	..	..	..	40	–5	15	50	–10	20	45	10	29	

I = Wrought iron; TLL = Tin-lined lead; L = Lead. WC = Water company. E = Electricity; HW = Hot water; S = Steam; F = Fire. O = C = Owner = Consumer on premises receiving water. * Each party pays on his premises.

Ave.	WATER. Source of Supply.	WATER. Ave. Temp. Source.	WATER. Min. Temp. Source.	WATER. Min. Temp. in System.	FROST. Soil Having Greatest Depth.	FROST. Greatest Depth Noted.	FROST. Ave. Depth.	FROST. Depth of Snow on Ground.	INCOME. Allowance to Consumer for Water Wasted through Meter to Prevent Freezing.	INCOME. Charge to Consumer if Meter Was Out for a Long Time.
	Surface	....	....	....	.....	6.0	4.5	1.0	Average consumption	None.
1	Surface; wells	45	40	32	Gravel; sand	2.5	2.0	None	None.	Annual minimum.
.	Lake	34	....	....	Gravel	6.5	4.5	1.5	No.	Average consumption.
.	Surface	34	33	....	Clay	5.0	4.0	Varied	No.	None left out.
.	Pond	....	....	....	.....	4.5	3.5	3–4	None.	No.
.	River	....	....	....	Gravel	7.0	4.5	3.0		Regular rate.
.	Springs	....	....	....	Clayey	5.0	...	Varied		Minimum rate only.
.	Surface	Met.	....	....	Gravel	6.0	4.0	8″–12″ ice		Prorated.
.	Surface	....	....	....	.....	...	...	.....	None.	Average for last year.
4	Surface	34	....	....	Gravel	6.0	5.0	9″ ice	Average winter consumption.	
7	Surface	....	33	....	.....	...	...	Very little	Average winter consumption.	
.	River	....	....	....	Gravel	6.0	3.5	+3.0	Average for last 3 months.	
.	Surface	32	32	....	Clayey	4.0	3.5	10″	None.	Similar period last year.
.	Reservoir	....	40	....	.....	5.0	...	8″–10″	None.	Prorated.
.	Surface	....	....	....	Sand	6.5	5.5	.....	City assumes one half above average.	Average of previous four quarters.
.	Wells	46	46	42–33	.....	5.0	...	Bare	None.	Similar to quarter last year.
.	Wells	50	....	....	Gravel	6.0	4.5	1.5	None.	Average.
.	River	56	33	33	Clay	4.0	2.0	1.0	None.	Average for 6 months previous.
.	Springs; surface	....	....	....	Sandy	6.0	2.5	.....	Not decided.	Same period last year.
.	Surface	....	....	....	Gravel	6.0	...	Lot	No charge if so ordered.	No if not ordered, prorate if ordered.
.	Wells	....	....	....	.....	...	...	.....	None.	No cases.
.	Surface; wells	....	....	....	Sand; clay; gravel	5.0	4.0	8″	Average 4 previous bills.	Average consumption.
.	Surface	37	36.5	....	Sandy	6.0	5.0	3″ ice; 3″-6″ snow	None asked.	Average consumption.
5	River	34	34	....	Clay	4.5	4.0	9″	None.	No case.
.	Wells	....	....	39	Gravel	6.0	...	Little	All excess over same quarter last year.	No.
.	Surface	....	....	....	Macadam	5.0	4.0	3.3	None.	Prorate.
0	River	....	....	....	.....	6.0	...	.....	Few cases.	Prorate.
6	Dug well	....	....	43	Sand	4.5	3.5	1.0		
.	Pond; springs	....	....	....	Clay	3.7	3.0	3.0	Owner pays all.	Prorate.
1	Lake	32	32	32	Clay; rock	9.0	6.5	2.0	One-half rate.	Estimated on size of stream.
.	Springs	....	....	....	Sandy	5.5	4.0	6″	None.	Prorate.
.	Wells	....	....	....						
5	Surface	....	....	....	Sand	6.3	4.0	Little	Corresponding time last year.	Corresponding time last year.
.	Wells	....	....	....	All	4.5	3.7	None	None.	Corresponding time last year.
.	Lake	....	....	....	Sandy	5.0	3.0	Little		Prorate.
.	Wells	49	49	....	Sand	6.0	4.0	Little	None.	Regular semi-annual charge.
.	Springs	....	....	....	Gravel	6.0	6.0	3.0	Average for previous 4 quarters.	
.	Springs; surface	....	....	....	Sand	5.8	4.3	.....	None.	Average same period last year.
.	Surface	....	....	....	Sand; gravel	6.0	4.5	2.0	None.	No cases.
.	Surface	....	....	35	Sand; gravel	5.0	5.0	4.0	No cases.	Similar period last year.
8	Surface	33	33	34	Gravel	6.0	3.0	1.0	None.	On basis of previous month's use.
.	Surface	40	36	42	Gravel	6.0	5.0	1.0	Average based on former use.	
.	Springs; surface	....	....	....	Gravel	5.0	4.0	8″	None.	Average for previous 6 months.
.	Surface	....	....	....	Clayey; gravel	5.0	...	.....	Flat-rate system.	
.	Wells	....	....	....	Sand	5.5	4.5	Little	In a few cases.	Half the usual rate.
.	Lake	....	....	....	Clay	5.0	4.0	2.0	None.	No ca e.
.	Springs	....	....	....	Gravel	5.0	4.0	3.0	None.	Similar period last year.
.	Surface	....	....	....	Coarse gravel	7.0	5.0	1.3	Normal average daily rate consumption.	
.	.....	....	....	....	Sandy	7.0	5.5	0.5	Allowance on dead ends.	Meters not out.
.	Wells	....	....	....	.....	5.0	...	.....	Few consumers paid one half cost.	Heavy takers paid at rate for same period of 1916.
7	Lake	....	....	....	Sand; clay	6.0	5.0	10″	One half owner; one half municipality.	Average for month before and after.
.	Surface	....	....	....	Gravel; sand	5.0	4.0	Little	Meter removed.	Average consumption charged at meter rates.
.	Wells	....	....	....	Gravel	5.5	4.0	3.0	Average consumption.	
6	Surface	51	36.5	34	Coarse gravel	6.0	4.0	.....	Consumption of same quarter for previous years.	
4	Wells	50	55	50	Clay	4.0	3.0	1.5	None.	Previous months.
2	Pond	34	....	....	Sand	4.0	2.0	.....	None.	Estimate.
5	Spring; brook	39	34	....	Sand; gravel	5.0	...	Little	Difference between actual and normal consumption.	
4	Surface	....	....	38	Gravel	6.0	4.5	None	Not decided.	Estimated at usual flow.
.	Wells	48	....	....	Clayey; gravel	5.0	...	.....	No cases.	No cases.
.	Surface	....	....	....	Gravel; sand	5.8	3.5	None	None.	Estimated on amount used.
.	Surface	....	....	....	Clay; marl	3.0	2.0	2″	None.	Same period last recorded.
1	Surface	50	33	34	Sand; clay	4.5	3.5	.....	None.	Charge based on subsequent quarter.
.	Surface	....	....	....	Gravel	5.5	4.5	1.0–1.3	No cases known.	Same period last year.
.	Surface	....	....	....	Gravel	4.0	3.5	1.0	25% of amt. in excess of same period last year.	No.
.	Surface	....	....	....	All alike	6.8	5.0	None	No systematic allowance.	On bases of former consumption.
4	Rivers	36	32	....	Soft rock	3.5	3.0	6″ or less	None.	Based on meter rds. before removal.
3	Surface	....	....	....	Gravel	6.5	5.5	1.0	None.	Same period last year.
.	Surface	....	....	....	Clayey	6.0	4.5	None	Sent bill for same amount as in winter 1916–17.	
7	Surface	40	33	35–40						
0	River	34.1	32	33	Gravel	7.0	5.5	Little	Excess over corresponding period of last year.	
.	Surface	....	....	31	Gravel	6.7	5.0	Little	Yes.	Prorated.
.	Wells	52	....	....	Rock; gravel	5.0	...	Light	Yes.	Average of previous years.
7	Surface	....	....	....	Gravel	6.0	4.0	2.0	City stands loss.	Yes, minimum.
6	Lake	....	....	....	.....	5.0	4.0	5″	Bill was prorated on normal consumption.	
.	Lake	....	....	....	Gravel	6.0	4.5	1.0	Flat rate.	No.
.	Surface	....	....	....	Gravel	5.0	3.0	1.5	None.	No cases.
.	Surface	49	34	....	Clay	8.0	6.0	2.5	None.	Previous consumption.
8	Wells; lake	50	35	35	Sand; gravel	9.0	7.5	Little	Freeze on owner, full charge. Freeze in street, normal charge.	None.
.	Surface	....	....	....	Gravel	5.5	3.0	2–3.0	None.	Yes.
.	Surface	....	33	....	Gravel	7.5	6.0	1″	Average quarterly when ordered.	Minimum.
.	Surface	....	....	....	Sand	6.0	5.0	2.5	None.	Same amount previous year.
3	Surface	33	33	33	Sand; gravel	7.0	5.5	1.0	Same as quarter last year if ordered to waste.	
.	Surface	....	....	33	Sand	5.0	4.0	3″–6″	No data.	
.	Surface	....	....	....	Clay; gravel	5.0	4.0	2.5	None.	Prorate.
5	Surface	....	....	....	Gravel	6.0	4.5	3″	Not determined.	Estimate based on ordinary consumption.
5	Surface	....	....	33	Wet clay	5.7	5.5	7″	None.	No case.
.	Surface	....	....	....	Clay; rock	6.0	3.0	1.5	None.	Prorate.
.	Surface	....	....	....	Dry sandy soil	4.8	4.3	6″–8″	Half over normal.	Average rate of consumption.
.	Wells	52	51	32	.....	6.0	5	Little	When so ordered.	Average consumption.
.	Wells	35	34	32	Gravel	6.0	...	6″	Excess abated.	Average rate for previous month.
.	Surface	....	....	....	Gravel	5.0	...	2.0	None.	Same as previous month.
.	Surface	....	....	....	Gravel	5.0	4.0	None	Normal consumption based on previous quarter.	
.	Surface	....	....	....	Dry sand	4.5	4.0	8″–12″	None.	Last year's record for same period.
.	Wells	45	45	45	Gravel	8.0	6.0	6″	None.	Yes, based on previous quarter.
.	Surface	....	....	....	Gravel	7.5	4.5	Little	All used allowed.	No cases.
9	Surface	41	40	37	Gravel	6.5	4.5	6″	Billed same as on last quarter.	

† Included in total. ‡ Includes outside.



CAMP DEVENS.

CAMP DEVENS.

could have been chosen, and to his poise, temperament, ability, courage, and knowledge of how far action might proceed in the absence of direct orders from Washington, the completion of the cantonment within the time limit is to be largely credited.

The Contract.

The contractor was selected on the basis of experience and capacity, not by competition — the reason for such action being set forth in the preamble to the contract, which reads that, "whereas war exists and the United States urgently needs the work hereunder described, whereas because of disturbed conditions it is advisable to depart from usual procedure, and whereas the contractor has had experience, has an organization and is ready."

The contract was of the cost plus a sliding-scale fee with maximum upset fee type, the percentage reducing with increasing value of contract and the fee under no conditions to exceed $250 000. The contractor was to furnish all labor, tools, supplies, and equipment, and all material not purchased by the Cantonment Division. He was to be paid a percentage on all costs except freight on material ordered from Washington, including transporting, unloading, repairing, and dismantling equipment; the salaries of his resident engineers and superintendents; on fees for bonds, — in short, on the entire cost of the work in the field as it might be determined by the constructing quartermaster after checking of all labor and all materials by the field auditor. The contractor was allowed a definite schedule of rental for equipment, and he was not to depart from the scale of wages paid in the locality without the previous consent of the constructing quartermaster. No salaries of executives, no expense of the contractor's main office, no overhead, and no interest on capital or borrowed money was allowed. Above all other elements in the contract was the requirement that, in the shortest possible time, the contractor should furnish the labor, materials, tools, machinery, equipment, facilities, and supplies necessary to the completion of the work. With time of completion so important, and with so much of the designing necessarily done from day to day, as data were collected after the work started, no form of contract other than cost plus a

fee was practicable, particularly in view of the existing conditions of the labor and material markets.

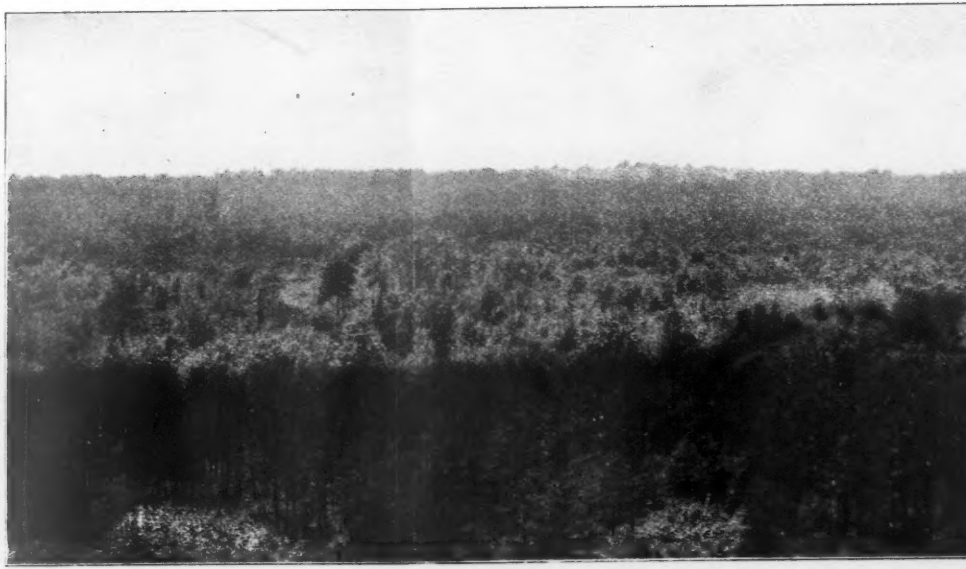
As to the cost of the work, while materials were generally purchased well below the market level, the prices paid for labor and the lowered standard of production inevitably made the cost greater than would be the case under more normal conditions. In the opinion of the writer, the organization and management of the contractor were good, and the work done as economically as the existing circumstances permitted.

The following tabulation shows the prices paid for labor and the maximum number employed. Lower prices would not have made possible the obtaining of the men necessary to the completion of the work in the time required.

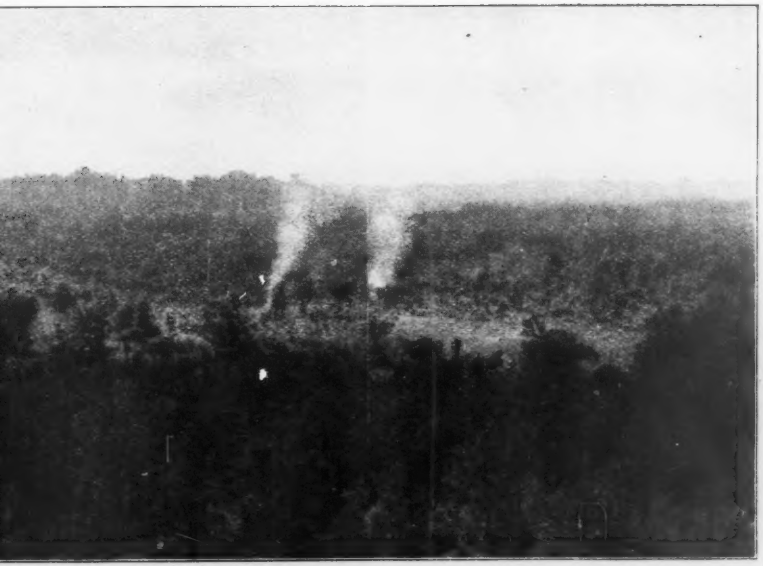
	Wages per Hour.	Per 10-Hour Day.	Time Over 8 Hours.	Maximum Number Employed.
Laborers	$0.37½	$4.13	Time and a half	5 000
Carpenters	.65	7.15	Time and a half	3 500
Electricians	.70	7.70	Time and a half	90
Steamfitters	.78	9.36	Double time	300
Plumbers	.70	8.40	Double time	175
Cement finishers	.70	7.70	Time and a half	75
Shovel runners	.83⅓	10.00	Double time	8
Tinsmith	.70½	8.46	Double time	30
Steam-fitters' helpers	.48	5.76	Double time	100
Blacksmiths	.50	5.50	Time and a half	40
Painters	.62½	6.87	Time and a half	40
Masons	.75	8.25	Time and a half	10

A government field auditor and a large force of assistants checked all material delivered, took the time of all men employed in the work, inventoried all equipment, witnessed payment of wages, and in general was responsible for the approval of all bills for labor, material, and other expenses as a precedent to the issuing of a government check by the constructing quartermaster.

Payments to the contractor were to be made as soon as bills were approved and the money was available, but, despite this arrangement, the amount of the contractor's money tied up was, at times, very large, and after allowing for overhead and interest charges, for which the Government made no allowance, the actual net return to the contractor was probably less than two per cent. of the value of the contract as completed.



SITE OF CAMP DEVENS, JULY 6.



Housing and Feeding Construction Force.

Before undertaking the description of the work done, a word as to the housing and feeding of the employees and the sanitary control of the camp during construction may be of interest.

The location of the cantonment made necessary provision for housing and feeding practically all the men engaged on the work — or a maximum at one time of 9 176 men. On June 19 the first of the contractor's force came on the grounds accompanied by a carload of tents for temporary purposes. The erection of telephone lines, an office 43 ft. by 306 ft. the latter built in less than thirty-six hours), and wooden barracks of which there were forty (each 16 ft. by 104 ft.), for the housing of the laborers, constituted the first work done. As the barracks were completed, the mechanics were moved from the tents and housed therein — an attempt at economy which later experience proved a mistake, when it was found that a number of the barracks were infested by bedbugs.

In all — including laborers' quarters, offices, sawmills, stables, shops, and storerooms — the contractor constructed 150 temporary buildings, at an expense of approximately $325 000.

A commissary was provided by the contractor and operated under a subcontract by the Baldwin Company, meals being served on the cafeteria plan at actual cost, as determined by auditing of all accounts, — the Government furnishing all equipment and supplies and the subcontractor being paid a lump sum for his services in management during the run of the work. Thirty buildings were erected for commissary purposes, 400 men being employed in this department, and over 17 000 meals being served per day.

The obtaining of a temporary water supply was one of the early problems — solved at first by the driving of two small groups of $2\frac{1}{2}$ wells and pumping to small wooden tanks located near the contractor's office and the stables.

As soon as the necessary pipe could be obtained, an 8-in. connection was made with the system of the town of Ayer — this system having been proved capable of furnishing 250 000 to 500 000 gal. per day in excess of the town's needs, by a test-pump run of ten days at maximum capacity. For distribution of the temporary supplies, wrought-iron or steel pipe laid on the surface was used.

Sanitary Work during Construction.

The sanitary control of the camp during construction, necessary to keep it clean and healthy for the incoming troops, was one of the big problems. With 9 000 men (the majority living and eating within the confines of the work), with no sewerage facilities, with a highly polluted river flowing past one of its boundaries, and with several small bodies of water within its limits ripe for the development of malaria via the mosquito route, there was obvious opportunity for the exercise of skill in meeting the problem. Fortunately, in Capt. (now Lieut.-Col.) Glen I. Jones, U. S. Army, who reported to the constructing quartermaster on June 19, as sanitary officer, the right man for the work appeared, and to his ability, technical knowledge, hard work, insistence that orders be followed, and ability to tactfully coöperate with all elements, is due the fact of an entire absence of insect, food, or water-borne disease during the period of construction.

A brief description of the work of the sanitary corps may be of interest, and perhaps of value in other similar undertakings.

First, in the absence of a water supply, all wells on adjacent farms were examined and the water analyzed. As is too frequently the custom, the wells were often too near the premises and the water found to be contaminated. Signs forbidding the use of such water were posted; but to these the workmen gave little heed, and all dangerous wells and springs were soon filled up. Systematic analyses were made of all water of which the use was permitted.

Another phase of the early work was the prevention of such soil pollution by human excrement, garbage, and waste water as might result in the transmission of disease. Pits 9 ft. deep, 11.5 ft. long, and 22 in. wide were dug for the reception of excreta. These pits were covered with wooden boxes, with six holes cut in the top — the holes having self-closing covers. The boxes were sealed tight with sand at the ground surface, and a tin funnel, connected through the side, served as a urinal and prevented soiling of the seats — the entire arrangement being intended to make the pits absolutely fly-proof. As many as twenty latrines of the type just described were placed in a single day, and soon there was no excuse for any workman fouling the surface

of the ground. The boxes were daily burned out with fuel oil and straw, unslaked lime was deposited in the pits, the inside of the box swabbed with a mixture of lampblack and oil, and the seats scrubbed with soap and water and standard disinfectant — all this to make an unfavorable breeding place for flies. When filled to within 18 in. of the top, the pits were burned, filled with earth to the surface, covered with burlap soaked in fuel oil (to trap flies and larvæ), and this again covered with additional earth to a level several inches above the ground surface.

Kitchen drainage from the commissary was discharged into cesspools in porous soil, these cesspools being burned and back-filled as soon as plugged by grease, and others excavated. All garbage from kitchen and from the laborers' shanties was systematically burned.

Examination proved that the malaria-carrying type of mosquito was present in considerable numbers in the area adjacent to the small ponds, near which the laborers' shanties were located. Work was therefore necessary to prevent the development and spread of malaria. Rifle Butt pond and several other small bodies of stagnant water were filled or drained, and the larger ponds were treated with fuel oil by the drip system — 5-gal. cans being placed at the shore line on the four points of the compass with wicks stuck in holes in the bottoms of the cans. The slowly dropping oil, spread by wind action, effectively covered the entire surface, and soon mosquitoes practically disappeared from the work.

To meet the danger of infection by typhoid carriers, all those working in the commissary and having to do with the food were subjected to the usual test. One typhoid carrier was found and discharged — this one case fully justifying the precaution.

Reports were obtained from the State Board of Health of any epidemic condition of typhoid or other infectious epidemics in the state, and of any cases which apparently had originated in the camp. No such latter cases were reported, but advices as to typhoid and diphtheria in Gardner were made the basis of discharging some twenty mechanics from that town, to prevent infection due to their returning home at the end of each week.

Open-air shower-baths were constructed near the laborers' and

mechanics' quarters, and orders were issued that these facilities should be used by the workmen. It was thought by some that the laborers might not respond, but such was not the case, the Italians and other foreign laborers eagerly taking advantage of the opportunity for cleanliness, and proving much more amenable to sanitary regulation than the mechanics. The work of the sanitary corps cost about $100 per day; the record of having prevented — in a camp of 9 000 workmen without sewerage facilities — the development of any case of infectious disease speaks for itself. For the preceding description of the work done in sanitation the writer is largely indebted to a statement prepared by Lieut.-Col. Jones.

Engineering Work in the Field.

General plans of the cantonment showing typical layouts of the regimental units, — either in a straight line or U-shaped, — typical plans of the arrangement of buildings in each unit, typical plans of the layout of water distribution and sewerage systems, detailed plans of buildings, plumbing, piping, and wiring and general specifications of all work, were furnished from Washington.

The engineering work on the ground included the making of topographical surveys, the adapting of the general layout to local conditions, the discovery and planning of the water supply, the design of sewerage and sewage-disposal systems, the planning of electric supply and distribution lines, the planning of the central heating plants and distribution lines, the staking out of all buildings, roads, water pipes, sewers, drains, electric and heating lines, and the supervision and inspection of the work.

The furnishing of typical plans of layout, detailed plans of standard structures and general specifications so as to insure that the results in all cantonments would be uniform and right in the essential elements, and the delegation of sufficient authority to those in the field to adapt these plans to local conditions alone made possible the progress necessary to completion within the scheduled time, and to those men, who planned this division of responsibility between Cantonment Headquarters and the constructing quartermaster on the job, great credit is due.

NASHUA
BASE HOSPITAL
PARADE GROUND
ROBBINS POND
TUFTS POND
COICUS HILL
HAND GRENADE FIELD
TO WORCESTER
BOSTON & MAINE R.R. WORCESTER, NASHUA & PORTLAND DIVISION
BUILDINGS SHOWN THUS ARE TEMPORARY BUILDINGS FOR CONSTRUCTION PURPOSES OR EXISTING
BUILDINGS SHOWN THUS PERTAIN TO THE CAMP
INDICATES WATER PIPE
INDICATES SEWER PIPE SEWERS WITH SIZES NOT MARKED ARE 8" DIAMETER.

CAMP DEVENS, AYER, MASS.

GENERAL PLAN SHOWING

LAYOUT OF CANTONMENT, BASE HOSPITAL

REMOUNT STATION, RIFLE RANGES

WATER SUPPLY & SEWAGE DISPOSAL BEDS

NOVEMBER 1917.

MAJOR EDWARD CANFIELD, JR. CONSTRUCTING QUARTERMASTER

FRANK A. BARBOUR, SUPERVISING ENGINEER

General Layout of Cantonment.

Camp Devens was originally planned for a division of troops consisting of ten regiments of infantry, three of artillery, one engineers' regiment, one field signal and telegraph battalion, one division headquarters, and ammunition, supply, engineers,' and headquarters' trains — or for approximately 38 000 men and 12 000 horses.

The typical general layout called for two main parallel roads — about 70 ft. apart — extending through the camp, along which were to be strung the various regimental units with occasional breaks for fire stops. Between these roads are located the barracks and lavatories, and at intervals of some 400 ft. connecting crossroads gave access to the kitchen end of the barracks. Along the outside road the regimental storehouses were placed — this road serving as the main artery for travel and for the transportation of supplies from the division storehouses located at the railroad. This road also formed the line between the men's quarters and the stables and sheds. Inside of the inside parallel road the officers' quarters were located, facing the drill field or parade ground.

At Ayer the rough topography and area available made it necessary to materially depart from the typical straight-line or U-shape plan — the layout comprising a pear-shaped section on the lower ground with the apex of its larger circle resting on the tracks of the Worcester and Nashua Division of the Boston and Maine Railroad (where the storehouses, coal trestle, and refrigeration plant were located), and its smaller apex pointing westward towards the Nashua River, together with a rectangular annex extending southwesterly over the higher plateau. Further to the southwest, on high ground overlooking the Nashua River, the hospital was placed, and about a mile to the north were located the rifle ranges and the remount station.

Type and Number of Principal Buildings.

Taking as an example an infantry regiment, the typical unit layout consisted of twelve two-story barrack buildings grouped in three rows and twelve lavatories, one for each barracks building.

A Company Street.

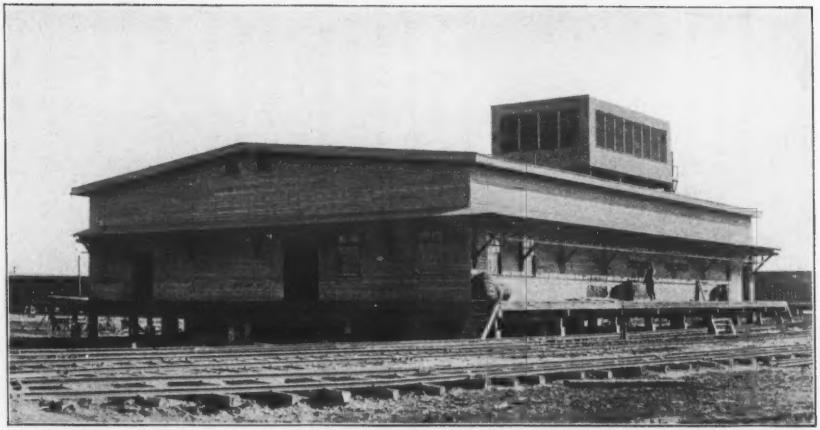
Y. M. C. A. Assembly Hall.

After considerable discussion of the relative merits of canvas and of wooden barracks, it had been decided by the Secretary of War to use wood in the sixteen cantonments, and to provide all reasonable water, sewerage, heating, and lighting facilities — such as would encourage maximum cleanliness, guarantee the best sanitary conditions, and make the first experience of camp life not too rough to the new army of conscripted citizens.

The original barrack buildings for infantry were two-story structures 43 ft. by 140 ft. by 18 ft. from sill to wall plate — the upper floor and one half of the lower floor being devoted to sleeping quarters and the remainder of the lower floor to mess hall and kitchen. These barracks were originally designed to hold 200 men — giving about 375 cu. ft. of air per man. Before completing of the cantonment, however, modifications were made, and additional buildings added so as to increase the air volume to about 500 cu. ft. per man.

Wooden posts, sunk 3.5 ft. in the ground, with footing blocks, form the support. The walls consist of one-ply roofing felt placed on the studs and covered on the outside with novelty or shiplap siding, with wooden sheathing on the inside to the bottom of the windows and wallboard above this level, the enclosed air space thus providing good insulation. Floors consisted of two thicknesses of boards with paper between. The roof was boarded and covered with two-ply felt, and provided with a ventilator extending along the ridge. All buildings were electric lighted and heated either by steam or stoves. Officers' quarters were 20 ft. wide and of varying length, the standard room being 8 ft. 4 in. by 10 ft. 6 in. by 7 ft. 6 in. high, and containing 650 cu. ft. The officers' quarters were boarded and covered on outside by battened roofing felt without exterior siding, and lined with wallboard.

The lavatories have a concrete floor and foundation well, and vary in size — that for a 200-men barracks being 21 ft. by 56 ft. and containing 12 water-closets, 20 shower heads, 2 trough urinals, and 2 trough lavatories — the water from lavatories wasting through the urinals. The lavatories were heated and furnished with hot water for the showers from horizontal steel tank heaters with steam coils, when the building was steam heated, and with vertical heaters, burning anthracite coal, where stove heated.



THE REFRIGERATING PLANT.

The rough topography and the abrupt changes in ground surface made the work of setting batters quite an undertaking, and, with one end of a 200-men barracks sunk several feet in the ground, the posts on the other end were frequently 12 ft. or more high. Cross bracing of these high posts and the boarding in of the irregular space below the lower floor was necessary and involved a very considerable expense.

In addition to the large two-story barracks, there are others varying in size from 30 ft. by 60 ft. to 30 ft. by 80 ft. — the total barracks and officers' quarters equaling about one quarter of the total number (approximately 1 400) of buildings in the cantonment. The other buildings include 338 lavatories, 20 administration buildings, 15 regimental medical buildings, 43 regimental storehouses, 12 divisional storehouses, a remount depot of 62 buildings with provision for 6 000 horses, 331 stables, wagon sheds and shops, guard houses, fire stations, a bakery with capacity of 40 000 loaves per day, a refrigerating plant of 20 tons capacity per day, a laundry collection building, a post-office, a telephone and telegraph building, a library building, a garbage transfer station and incinerator, 5 garages, 4 magazine buildings, 13 Y. M. C. A. and 3 Knights of Columbus buildings, the Hostess House of the Y. W. C. A., a Y. M. C. A. auditorium with capacity for 3 000 people, 2 theaters, one with seating capacity of 3 000, 11 post exchanges, and a base hospital of 60 buildings connected by glazed corridors $1\frac{1}{4}$ miles in length.

A total of about 44 000 000 ft. of lumber was used — in great part of northern spruce — in order to avoid the railroad congestion which was most pronounced on the railroads to the south. Some 4 miles of railroad track were laid for the receipt and handling of material, and 20 motor- and gasoline-driven sawmills were erected along a side track, by which the lumber was sawed to dimension, marked for its place in the work, and thence carted by truck or motor — there were 125 trucks and 200 teams — to the proper building. An average of 500 000 ft. of lumber per day was in this way handled, and an average of 45 carloads of all material was received daily between July 1 and September 1.

Electric Light and Power.

Electric energy for light and power is purchased from the New England Power Company and furnished from hydro-electric stations of 62 000 K.V.A. capacity, located at Vernon, Vt., and Shelburne Falls — these stations being interconnected by complete double circuits. For the supply of Camp Devens two separate pole lines, on private right-of-way, each carrying a 3-phase 66 000-volt line, were run from the camp to Leominster,— a distance of 8.2 miles, — where the circuit of the power company was tapped. No. 2 copper wire, supported by 4-disk suspended insulators from steel cross-arms on wooden poles, is the type of construction. Just outside the cantonment a stepdown substation was located. The high-tension equipment is of the outdoor type and includes two main-line oil switches, one complete set of electrolytic lightning arresters, and an integral high-tension metering unit. Three 500 K.V.A. water-cooled transformers, with voltage ratio of 66 000 to 2 200, are placed in a small asbestos, metal-covered building. The operating building is a brick structure and contains a 10-panel switchboard and all low-tension apparatus. Outgoing lines are provided with disconnecting switches, choke coils, and lightning arresters. Provision was made for the installation of potential regulators in all lighting feeders, but these have not proved necessary and have not been installed.

The substation was constructed by The Power Construction Company under a subcontract, and great credit is due President Geo. W. Bunnell (now Colonel 101st Engineers) and Mr. C. R. Oliver, electrical engineer of the company, for good work quickly done. The first requisition of material was made on July 18, and thirty-two days later the station was carrying load. Much of the material — as is true of a great part of the 135 miles of wire used in the camp — was shipped by express.

The primary circuits from the substation are 3-phase 2 200-volt, installed on the loop system — pole line oil switches so dividing the circuits that with the exception of the sewage pumping-station feeder, any section, in case of fire or other emergency, can be cut out and energy furnished through other paths, thus

making it unnecessary under any conditions to leave any large portion of the camp without current.

The secondary distribution is 110–220 volts, 3-wire, single-phase, — except for power services, — reduced from the primary voltage of 2 200 by 125 distribution transformers, which are protected by two lightning arresters on the primary side, these arresters being grounded to galvanized-iron pipe sunk 15 ft. into the ground. There is no secondary network — the secondaries on each side street being entirely separate from any other part of the system.

The street lighting system consists of three hundred 6.6 ampere, series, incandescent, gas-filled lamps of 100 candle-power each, controlled by a single 3-phase feeder from the station, with 3–10 kw. constant current transformers, each feeding one third of the camp, connected through pole line oil switches. The house services in the majority of the buildings are 3-wire 110–220 volts; in the case of stables and small buildings, 2-wire 110 volts. All interior wiring is concealed back of wallboard, knob and tube construction, run in accordance with plans furnished from Washington.

The standard lamp is a 50-watt, 113-volt Mazda lamp, the typical fixture having a drop cord, and socket with conical tin shade.

The power service includes that for the main water pumping and booster station and for the sewage pumping station. The primary voltage of 2 200 volts is carried to these points — the transformers at the main water-works stations being so tapped as to yield both 440 and 550 volts in accordance with the requirements of the pump motors.

The estimated load was 1 200 kw., and the annual energy demand 2 000 000 kw. hours.

Heating.

All infantry and artillery regimental units are heated by steam from central plants; all officers' quarters and medical buildings in other units are heated from individual steam plants; all other buildings are heated by stoves.

A total of 507 buildings — in addition to the hospital — are steam-heated, this requiring thirteen central plants — ten with ten 67-h.p. boilers and three with seven 67-h.p. boilers, and 43 small individual plants — the total horse-power, exclusive of the hospital, being 9 927. These boilers are all of the cast-iron sectional type — the use of this type in the central plants being due to the difficulty of obtaining steel boilers in the allotted time. At the base hospital ten horizontal tubular boilers of 150 h.p. each were originally installed, and two more have since been added.

The steam is distributed from the central plants to the different buildings through overhead mains supported from small telegraph poles by iron brackets and adjustable hangers, a total length of outside lines — 2-in. to 10-in. diameter — of 8 miles being required. The mains were anchored to the buildings, the pole bracket hangers providing for intermediate expansion.

No return system was provided, and all condensation was discharged through traps in the different buildings, and wasted into the ground outside. Recently, provision has been made for the return to the boilers of the condensation at the hospital.

Outside mains were covered with 4-ply asbestos air cell, two layers of sea-weed quilt and a layer of waterproof paper. Mains inside of buildings were not covered.

The system within the buildings includes distributing mains near the ceiling, drop pipes, with single connection to bottom of radiators, extending down to the return mains which lead to the traps through which the condensation is discharged outside the buildings. Radiation in barracks is in the proportion of one square foot to fifty cubic feet, and was calculated to furnish a temperature of 60 degrees in extreme weather.

A fourteen-hour test, from 5 A.M. to 7 P.M., of one central heating-plant, was made on November 27, 1917, with measurements of coal and water used and observations of outside and interior air temperature and steam temperature at different points in the distributing system. The results showed that with an average outside temperature of 18 degrees on the north side of buildings, and with an average boiler pressure of less than 7 lb., the middle barracks in a day of light winds could be heated to 80 degrees and the most distant buildings to a temperature of 78 degrees.

From this it was concluded that with the heating system the temperature of buildings could be maintained at 60 degrees, with an outside temperature of 10 degrees below zero.

This test was made at a time when the operators had not become accustomed to the firing of anthracite coal, and the evaporation was low, being only 6.0 lb. per pound of coal burned. Later, by the excellent work of Major E. W. Briggs and his assistants in the Utilities Department, much better results have been obtained. In particular, the area of grates has been reduced one third, thicker fires carried and the dampers better handled. In January, February, and March the actual evaporation of the thirteen central plants averaged 7.5 lb. of water per pound of coal burned.

The traps, of which there are 2 500 in the cantonment, are the weak points in the system. In the early days the rust and scale in the pipes continually clogged the small discharge openings, and constant, untiring inspection, disconnection, and cleaning is necessary to keep the traps in effective operation so as to prevent freezing.

The regulation of the amount of steam admitted to each barracks from the common main so as not unduly to heat those buildings nearest the central plant at the expense of the more distant, requires careful adjustment of the hand-operated control valves and constant watchfulness is necessary to prevent tampering, with these valves.

The waste of the condensation with the consequent demands on the water supply and coal pile might, at first thought, be criticized, but the validity of such criticism depends entirely on the number of years the camp is to be used during the winter months, and, so far as now appears, the omission of a return system was good engineering.

The steam installation was proved capable, during the unusually severe winter of 1917–18, of heating the buildings thus supplied to the temperatures contemplated in the design of the system.

It is also true that stoves proved apparently satisfactory to those occupying the buildings so heated. The sociability of a red-hot stove presumably makes up for the greater uniformity of temperatures provided by steam.

Roads.

The roads were not included in the general contract of Fred T. Ley & Co., this work being awarded to the Barrett Manufacturing Company of Boston.

The general contractor was, however, required to construct such temporary roads as were necessary for the transportation of some 3 000 carloads of building material. As these roads were in almost all cases on the location of the permanent highways, to avoid the confusion which might result from two contractors on the ground, and in order that the permanent roads might be turned over to the military authorities without the wear incident to the construction of the camp, the road contract was not let until August and was not completed until November.

The road system includes three types or classes of construction. The first class is limited to the outside belt road which encircles the camp, and is the main artery for the transportation of supplies from the divisional to the regimental storehouse and for general traffic. This road has a 6-in. Telford base of local field stone, — a 2-in. course of No. 1 crushed trap, bound by $1\frac{1}{2}$ gal. per square yard of high-carbon tar-penetration method, a thin covering of No. 2 trap sufficient to fill the voids and bound by one-half gallon per square yard of tar, a covering of pea stone, and a final application of one-quarter gallon of Tarvia B. No gravel or rocks suitable for crushing and use in the surfacing of first-class roads were found in the reservation, the crushed stone being brought in by railroad. The first-class roads have a width of 18 ft. of finished surface, with 6 ft. shoulders on either side. The total length is 6.90 miles.

The second-class roads are those forming the inner belt line which encircles the camp. These have a total length of 6.16 miles and are constructed of local run-of-bank gravel in two 4-in. layers, the top layer being water-bound.

The third-class roads are those which cross-connect the first- and second-class roads, and provide access to the kitchen end of barracks. The total length is 5.95 miles, and the construction of water-bound, rolled, run-of-bank, local gravel.

Sewerage and Sewage Disposal.

The sewerage system is designed for the removal of house sewage only, the connections being with the lavatories and with the kitchens of barracks.

The layout of the collecting system at Ayer is most irregular, owing to the broken topography, — the sewers being located to obtain the least cut without regard to the roadways. The main sewer follows the valley of Willow Brook and thence along the bank of the Nashua River to a pump well, located about a mile below the northern limits of the camp. Including the hospital and remount station, the total length of sewers laid was 13 miles, and of 6-in. connections to buildings, 10 miles.

The work was done in about fifty days, with an average rate of construction, for thirty-five days, of 3 100 ft. per day and 6 800 ft. as a maximum day's work. The average cut was 6.0 ft.; the maximum cut, 18.5 ft. Rock was encountered in a number of sections, and water and quicksand found along the main sewer. About 25 per cent. of the trenches required close sheeting, and about 25 per cent. of the excavation was done by trench machines. The joints in the main sewer are for the greater part of its length made with bituminous compound.

Vitrified clay grease-traps, 18 in. in diameter and with a capacity below the flow line of 13.2 gal., were placed on the majority of the kitchen connections. For the remainder, concrete box traps 3 ft. long by 2 ft. wide, with a capacity of 60 gal. below the flow line and with two wooden baffles, were constructed in place.

The vitrified traps are of practically no value in holding grease; the concrete traps are better, and retain enough grease to make skimming profitable, but a large part of the grease passes through, a fact made evident by the 15 tons of material — 63.5 per cent. fats in dry sample — removed on October 7, 1918, from the walls of the main pump well. Evidently larger and better designed traps are necessary to intercept grease from a camp kitchen so that it may be collected for its value. On the other hand, no stoppages have occurred in the lateral or main sewers, and none in the connections with concrete traps. About four per month on the connections with vitrified traps are recorded, but these are due in many cases to pieces of meat thrown into the trap. Aside

from the question of making possible the collection of the grease before its mixture with the sewage, a large grease trap on the main sewer would most effectively protect the filters.

Instructions furnished from Washington required that sewers, flowing full, be provided for maximum discharges of seven times the average flow in the case of single regimental units, to 2.85 times the average flow from the entire camp, the averages being based on the contributing population at 55 gal. per capita per day.

The actual flow for the week of August 18 to 24 — which illustrates maximum conditions as recorded — is shown in a diagram herewith presented. With an average population for the week of 44 580, and an average water consumption of 49.0 gal. per capita per day, the average sewage flow is 39.3 gal. per day per capita; the flow on Friday is 125 per cent. of the average day; the flow of the maximum hour on Friday is 185 per cent. of the average for that day, or 231 per cent. of average for week, and the maximum flow for fifteen minutes is 251 per cent. of the average for the week.

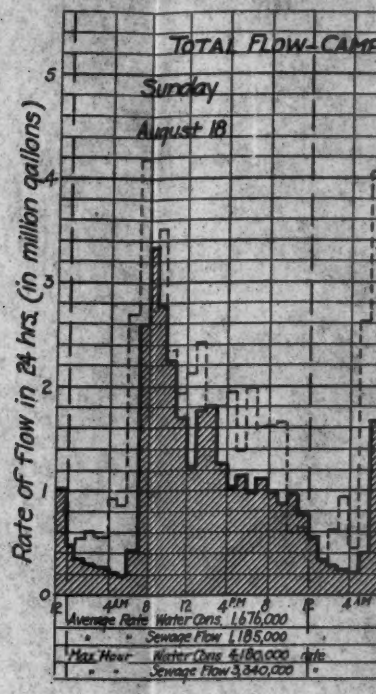
The Nashua River into which the sewage of the camp or the effluent from treatment works must flow has a total watershed of 420 square miles at Ayer. Of this area 118 sq. miles are pre-empted for the Metropolitan Water Supply, and the run-off diverted. To the dry-weather flow, available for the dilution of sewage from the cantonment not more than 300 sq. miles could be assumed to be contributory and for a considerable period the dry-weather flow might well be less than 100 sec.-ft. or sufficient for the adequate dilution of the sewage of not more than 20 000 people. Further, in the watershed of 300 sq. miles there is a population of 70 000 people, and only the city of Fitchburg has disposal works. The river as it reached the site of the camp was already highly polluted, and the State Department of Health had already taken steps toward the betterment of the stream conditions. There could be no question as to the necessity for treatment of the sewage, and such treatment as would involve some form of filters.

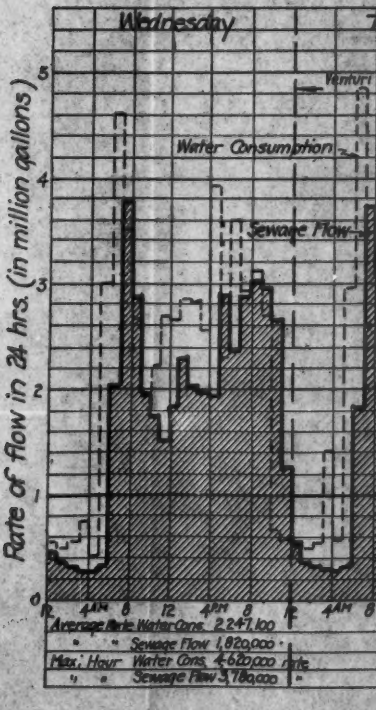
It was not possible to apply the sewage to any type of filter without pumping, and the solution of the disposal problem lay either in the use of settling tanks and some type of rapid filter in the valley, reached by low-lift pumping apparatus, or the con-

Diagram showing SEW

Based upon weir measurements
90% of total flow) and discharge

Water used for the following does not enter
transformer cooling, water works pumping sta
storehouses and garage, constructing quarte
uses throughout camp It is estimated tha



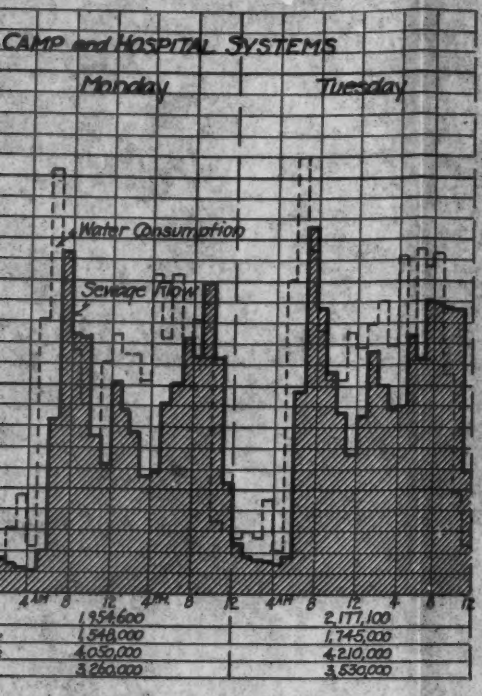


Maximum Sewage F

SEWAGE FLOW for week ending Aug. 24, 1918.

ents taken at 15 min. intervals for main camp system (approx.
arge of dosing tanks for Base Hospital systems.

enter the sewer – 7000 animals, steam for hot water heating, sub station
ping station, refrigerating plant, garbage station, bakery, quartermaster's
quartermaster's and camp utilities office and buildings, and numerous small
ted that the above averages approximately 300,000 gallons daily.



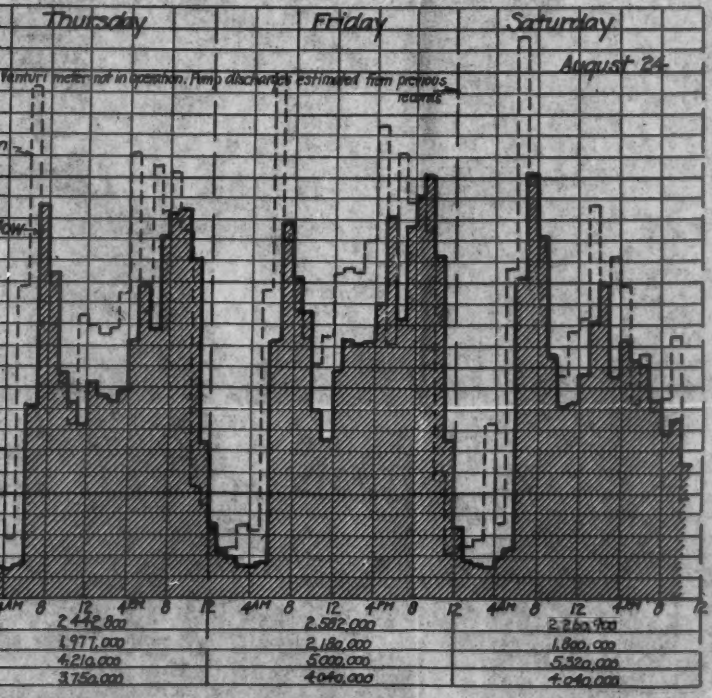
	1,954,600	2,177,100
	1,548,000	1,745,000
	4,050,000	4,210,000
	3,260,000	3,530,000

Base Hospital Flow

(Not including Convalescent wards)

Date	Population	Sewage total
18	1773	110,000
19	1764	127,500
20	1876	138,000
21	1934	135,500
22	1907	146,500
23	1917	150,000
24	2014	137,000

Max. hour 1.78 to 2.35 times average.
Min. " 0.35 to 0.40 " "


Thursday
Friday
Saturday
August 24
Venturi meter not in operation. Pump discharges estimated from previous records.
4AM 8 12 4PM 8 12 4AM 8 12 4PM 8 12 4AM 8 12 4PM 8 12

2,442,800	2,582,000	2,280,900
1,977,000	2,180,000	1,800,000
4,210,000	5,000,000	5,320,000
3,750,000	4,040,000	4,040,000

age Flow for 15 min. at rate of 4,400,000 gallons per 24 hrs.

struction of intermittent filters of sand in natural position, 80 ft. above the river. The latter method was chosen, and 20 acres of filters were prepared by stripping off the top soil and using it to form embankments. The distribution of the sewage is similar to that in other Massachusetts plants, but there are no underdrains; the depth of the sand to the water table — in excess of 12 ft. — and the elevation of the area above the adjacent river making artificial drainage unnecessary.

The gravity outfall sewer ends at the pump well, — a covered circular tank of concrete of 150 000 gal. capacity. The entering sewage is screened through bar screens of $\frac{5}{8}$-in. clear opening — smaller than general practice — to reduce liability of pump clogging to a minimum. An agitator consisting of an octagonal ring of 6-in. cast-iron pipe placed midway of radius of tank, tapped by 32 $\frac{3}{4}$-in. nozzles, and connected with the force main, was provided for the removal of any sludge deposits. Its use has been found unnecessary, as the floor slope of $1\frac{1}{2}$ ft. in radius of 30 ft. and the course of the entering sewage keeps the floor free from sludge deposit.

To prevent floating of the tank by a rise of the ground water during extremely high stages of the river, a 4-in. vitrified pipe, laid in screened ground around the outside of tank at an elevation 5 ft. above the bottom was connected with inside of tank, with check valves opening inwardly.

The sewage is raised to the filters by a centrifugal pump of 2 800 gal. per min. capacity driven by 100 h.p. motor. The force main is of 16- and 20-in. cast-iron pipe, 2 355 ft. long.

Water Supply.

The general specifications, furnished from Washington, required a supply of at least 55 gal. per day for each man in the cantonment; this including an allowance for animals and being based on 50 gal. per man and 15 gal. per horse or mule. It was further specified that through storage or otherwise, provision must be made for a maximum demand of 2.85 times the average rate, for a period of one hour.

These estimated requirements of a semi-permanent cantonment,

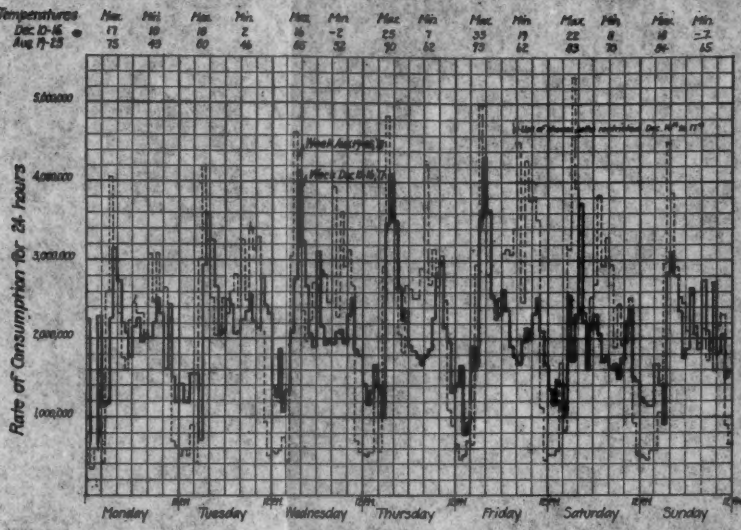
equipped with sanitary conveniences on a scale never before attempted, were necessarily made without the aid of recorded experiences under similar conditions. European allowances had ranged from 6.5 gal. by the French, $8\frac{3}{4}$ gal. by the Austrians, 11 gal. by the Germans to 20 gal. by the British, but for no such number and nearness of fixtures as were contemplated for the cantonments.

The actual record of the use of water, and a brief analysis of the results at Camp Devens, may therefore be of some interest. On one of the diagrams herewith presented there is shown the gross consumption, the consumption per capita, the population and the mean temperature for each week from October, 1917, to August, 1918. It is at once apparent that the varying population, which ranged from 20 000 to 45 000 men, and the demand for steam heating, are controlling factors in affecting the per capita use, which varies from 39.3 gal. per day in June to 81.5 gal. per day in January. The higher demand with reduced population is due to loss by leakage and to uses which are more or less constant and independent of population.

The water used for steam as measured by meters on all central heating plants from January to April was as follows:

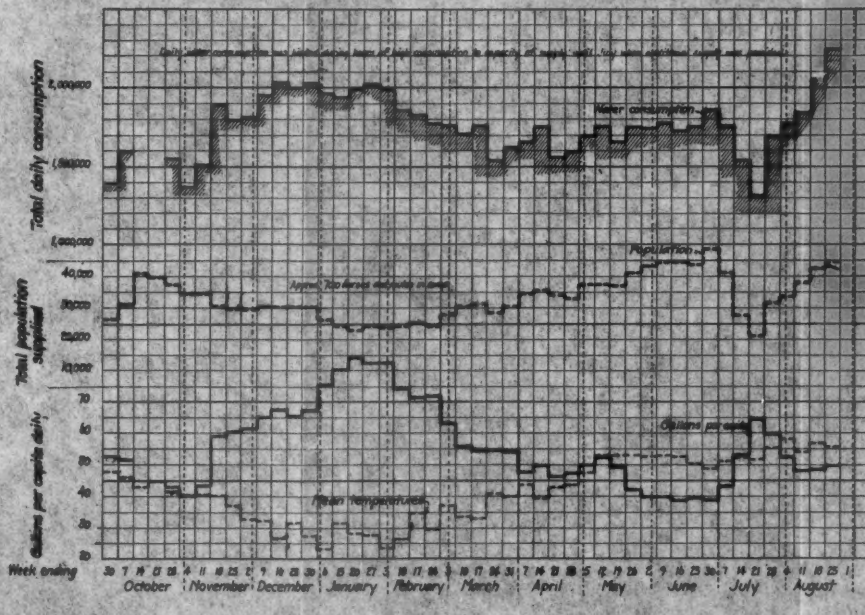
	Gal. per Day.		Gal. per Day.
January	676 000	March	343 000
February	491 000	April	242 500

Other fairly constant uses and losses may be estimated as follows: Leakage from mains, services, and fixtures, 200 000 gal. per day; animals, 100 000 gal.; pumping stations transformers, garbage station, etc., 20 000 gal.; steam for hot water in summer, 75 000 gal.; and the gross requirements, more or less independent of population, have ranged from 400 000 gal. per day in summer to 1 000 000 gal. per day in the month of extreme low temperature. If the amount so used for each month is deducted from the gross consumption, the balance, or the water directly dependent on population, is found to vary from approximately 30 gal. per capita per day in the spring months to 40 gal. per day in the hot months of the summer. Also it appears that, if the population had remained constant at 40 000 men, the gross consumption would

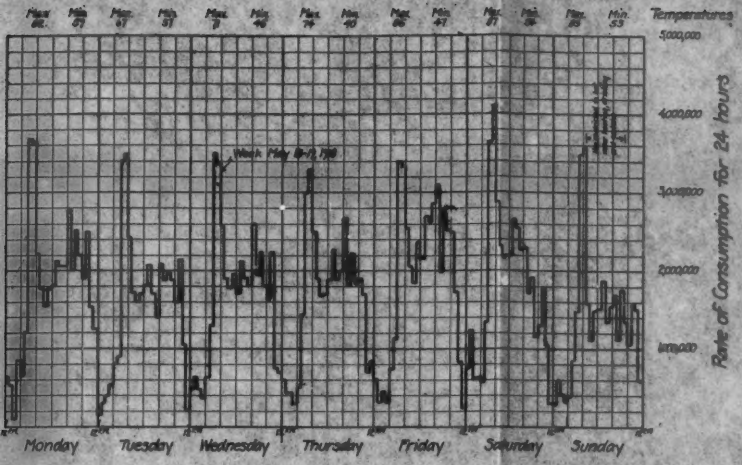


Hourly Consumption for weeks of Dec. 10-16, 1917 and Aug. 17-25, 1918.

Showing high night consumption in winter and peak loads in summer.

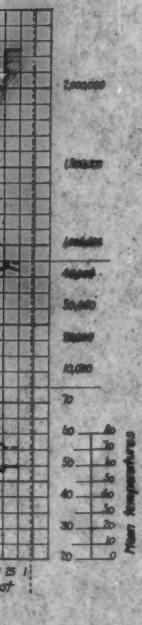


Average Daily Water Consumption, Population supplied, Use in Gallons per Capita.



Hourly Consumption for the week of May 13-19, 1918

Showing low night consumption



CAMP DEVENS—AYER, MASS.
—WATER SUPPLY—

DIAGRAMS SHOWING WATER CONSUMPTION

Sept 1, 1918

have ranged from 40 gal. per capita per day in the spring months to 65 gal. per capita per day in the month of extreme low temperature.

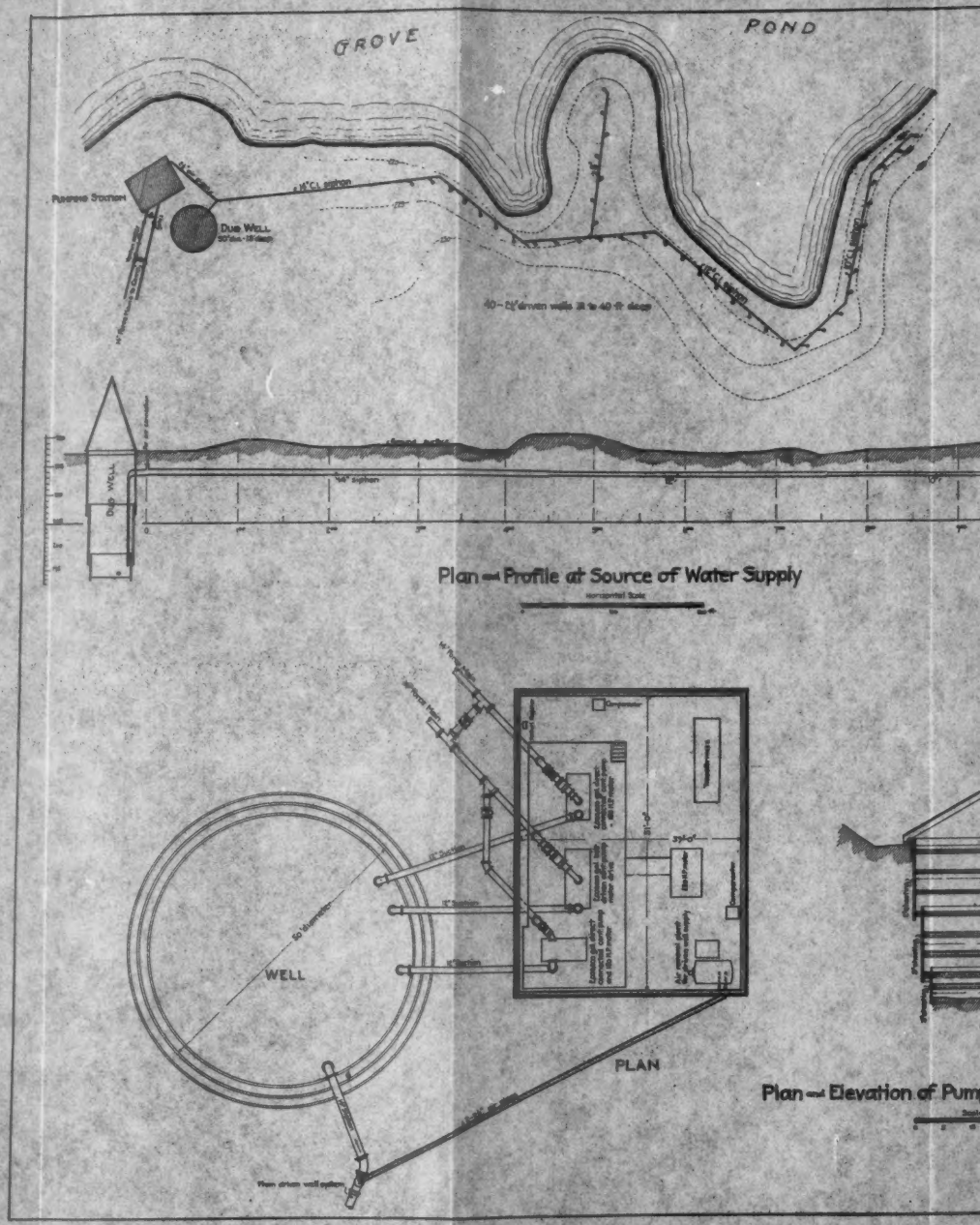
A diagram, herewith shown, of the consumption during a week in May best indicates, by the minimum night demand, the rate of leakage from mains, services, and fixtures. Another diagram shows the hourly variation during hot weather and in December when the steam requirement is the controlling factor.

To what extent the consumption at Camp Devens might be further reduced by more stringent regulation cannot be stated, but the relatively low use of water during the past summer has only been reached by the strenuous effort of the officer in charge of utilities. Self-closing faucets and wash basins for each man instead of a continuous stream while standing at the lavatory, faucets to supply hot water and thus do away with the temptation to use the shower-heads too frequently, and automatic valves to reduce the pressure in the lower areas of the camp, would all effect a saving of water, but would involve increased cost and difficulty in obtaining fixtures. The ingenious insertion by the Utilities Department of lead plugs $\frac{1}{2}$ in. long, tapered from $\frac{5}{8}$ to $\frac{3}{8}$ in., tapped by $\frac{1}{8}$-in. hole, just back of the faucets in the service pipes of the high-pressure area resulted in a substantial reduction in consumption, as has also the decreasing of the depth of water in the flush-closet tanks.

The use of water has been greatest on Friday, and exceeds the average for the week by about 10 per cent. The consumption during the maximum hour, which occurs in the early morning, is not of importance in determining the storage to be provided. The curves of hourly use at Camp Devens indicate a consumption for seventeen hours in excess of the average daily rate, and, on the assumption that the pump will operate at the average daily rate of consumption, it appears from the curves above referred to that, without allowance for fire service or any reserve, the storage necessary to meet the deficiency during these seventeen hours ranges from 20 to 25 per cent. of the total daily consumption during the summer months and from 10 to 15 per cent. during the winter months. Unless the rate of supply is made to vary to a greater or less degree with the hourly use, a storage of at least

25 per cent. of the maximum summer consumption plus that for fire service should be provided.

The supply is obtained from the ground near the shore of Grove Pond. The town of Ayer had for years been taking somewhat less than 200 000 gal. per day from 28 2½-in. wells located near this pond. Between June 1 and 20, 1917, the Preliminary Board of Engineers, assisted by Mr. W. S. Johnson, made a ten-day test run at a rate of 1 000 000 per twenty-four hours — indicator wells having been driven in various directions to show the effect of this rate on the adjacent water table. The resulting small depression of the ground water and the proof that a draft of 800 000 gal. per day could be maintained from the Ayer wells was taken as good evidence of the ability of the well field to furnish a supply of 2 000 000 gal. daily to the cantonment and also that from the Ayer system 250 000 to 500 000 gal. per day might be obtained as a temporary supply during construction. From the evidence of numerous test wells it was decided to excavate a well 50 ft. in diameter and 30 ft. deep at a point about 1 000 ft. east of the Boston & Maine Railroad and about 100 ft. from the shore line of the pond. A report of the Preliminary Board of Engineers to Brigadier-General Littell, dated June 21, 1917, reads that "it is believed that this well will furnish 1 500 000 gal. per day and perhaps more," and that if its capacity as determined by pumping during construction and by observation of water-table depression should prove less than 2 000 000 gal. per day, "2½-in. wells can be driven along the shore of the pond and arranged to siphon into the excavated well." This anticipation of the possible necessity of auxiliary driven wells proved true, for, while the pumping during construction indicated an available supply exceeding that required by the cantonment, the quantity which could be continuously drafted without lowering the water to a level dangerously near the bottom of the suction pipe was found after several months' use to be about 1 750 000 gal. per day. This was due in part to the fact that in the excavation of the well the bottom "blew up," carrying from lower depths large quantities of fine sand and thus sealing the bottom area to a certain extent and making the available draft dependent in great part on the water entering through the sides. The well was constructed by driving vertical wooden



Plan and Profile at Source of Water Supply

Plan and Elevation of Pum

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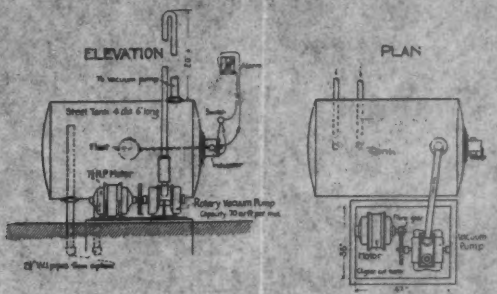
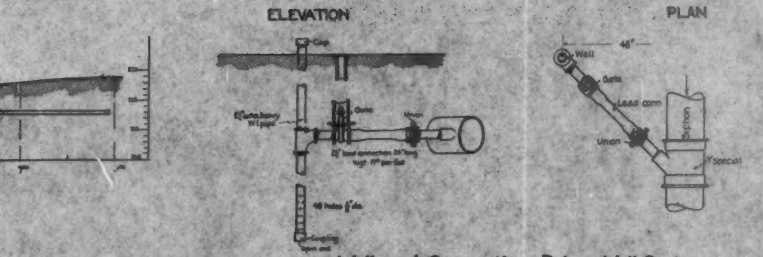
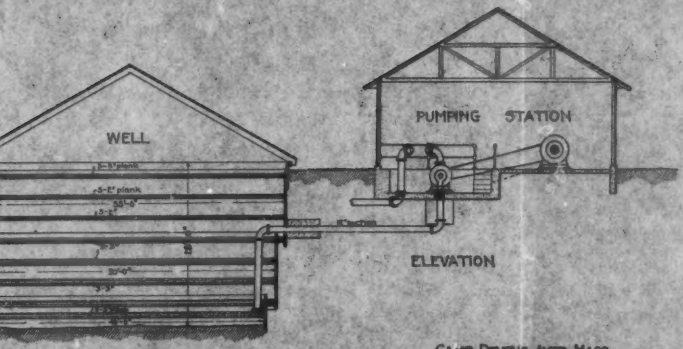


Air Removal Plant—Driven Well System.



Well and Connection—Driven Well System.



Pumping Station and Dug Well.

CAMP DEVENS, AYER, MASS.
—WATER SUPPLY—
Plan showing
SOURCE OF SUPPLY AND PUMPING STATION

Major Edward Canfield Jr Qmc.Q.M.
Major Edward W Briggs
F A Barbour, Supervising Engineer

Sheet No 8

sheeting in three sets back of circular ribs, this sheeting forming the permanent sides and no masonry being provided.

Observations of the elevation of the water table in test wells adjacent to the dug well established the fact that, while from the well less than 2 000 000 gal. per day were obtainable, there was ample supply in the adjacent well field, the water standing 8 ft. higher in the ground 50 ft. from the well than in the well when pumping at a rate of 2 000 000 gal. per day. Accordingly, the driving of 2½-in. wells was recommended on September 20, 1917, and these have since been provided although not available for use until June, 1918.

The method of hitching up these driven wells with the main supply may be of some interest. This is illustrated by a plan herewith presented and involves the carrying of the main suction pipe, to which the 40 wells are connected in the ordinary way, on a flat rising gradient to a point near the main well, from which point it turns down into the well so as to form a siphon. From the top of this suction pipe at the high point, two lines of 2½-in. pipes connect with a steel tank 4 ft. in diameter, 6 ft. long, and of 75 cu. ft. capacity — one line ending at the bottom of this tank and the other extending through the bottom and well towards the top. From the top of the tank a 2-in. pipe, rising to a height sufficient to prevent water being drawn over, connects with a rotary dry vacuum pump of 70 cu. ft. per minute air capacity driven by a 7.5 h.p. motor. The pump creates a vacuum in the siphon line and starts the flow of water from the driven wells to the main well at a rate dependent on the difference in level of the water in the driven wells and in the main well, and it also fills the tank with water. As air is released in the suction or siphon line it flows to the tank through the 2½-in. pipe which extends to the top of tank — the displaced water returning to the suction line by the other 2½-in. line. The tank thus provides storage for air outside of the siphon line which remains in continuous operation. When an alarm operated by float in tank indicates that the tank is full of air, the vacuum pump is again started, from one to two runs of a few minutes each being necessary daily.

To insure air-tightness in the siphon line each pipe and fitting was submerged in water and subjected to 100 lb. air pressure be-

fore being laid. About twelve lengths of pipe and several fittings, which by customary methods would pass inspection, were found to leak air — the leakage being always through the bells of the pipe and the top of fittings as cast. After laying, an air pressure of 50 lb. was applied to the suction line and all joints, which were made with a 3-in. depth of lead, and which had been covered for the test by a mixture of soap and water, were examined and recalked where necessary. It is believed that the test of individual pipe might safely have been omitted.

The supply has been more than ample for all requirements since the installation of the driven wells and the source, as now developed, is probably capable of furnishing 300 000 gal. per day.

The water has been of excellent quality, soft, free of metallic contents, cold in summer — maximum temperature about 52 degrees — and relatively warm in winter.

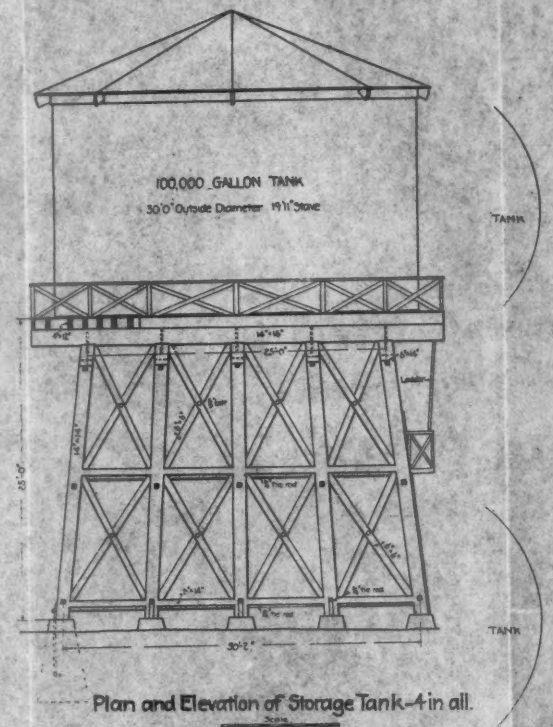
The pumping station is a wooden building and contains the transformers, switches, motors, and pumps. Two pumping units — one direct and one belt driven and each of 2 000 000 gal. per day capacity against a head of 250 ft. — were first installed; recently a third unit of the same capacity has been added.

From the pumping station two lines of 12-in. wood-stave pipe, each 6 175 ft. long, laid 40 ft. apart, lead to the cantonment. A Venturi meter records the amount pumped.

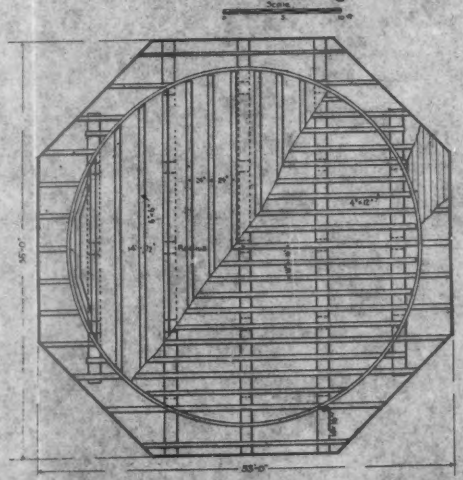
The distribution system follows, in general, the typical layout furnished from Washington, and comprises double loops of 8-in. wood-stave pipe, 500 ft. apart and located between and parallel to the main inside and outside circulating roads. These lines are connected to the storage tanks by two lines of 10-in. pipe; an 8-in. loop extends around the divisional storehouses, two 10-in. lines lead to the hospital, and an 8-in. line to the remount station.

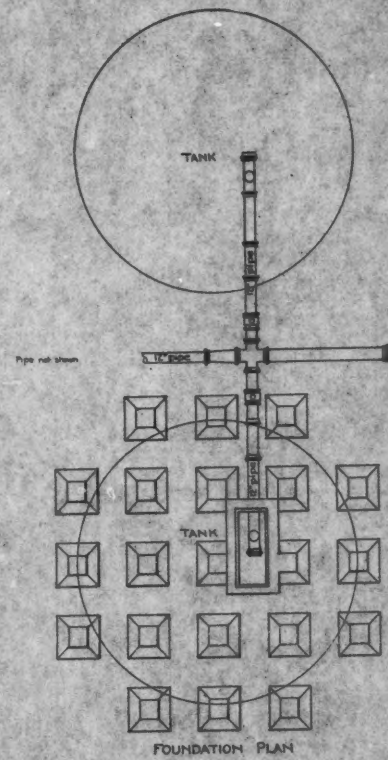
The total length of pipe — 4–12 in. in diameter — is 20.8 miles, of which 17.9 miles are of wood stave. In addition there are 17.8 miles of services ($\frac{3}{4}$ to 2 in.) of galvanized iron. Gate valves number 122, and 4-in. hydrants, 418.

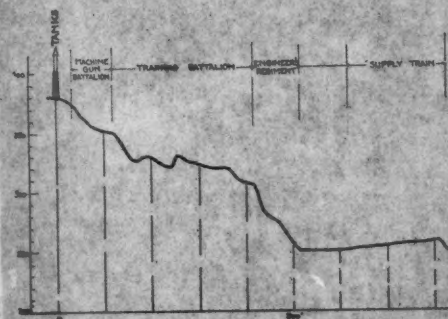
The stave pipe used is redwood, as are also the storage tanks. The pipes are machine-banded by spirally wound galvanized wire, with tenoned ends to fit wooden connecting collars which are also wire bound. Cast-iron fittings were used for hydrants, branches,



Plan and Elevation of Storage Tank-4 in all.







Typical Profile-Pumping Station to Tanks-

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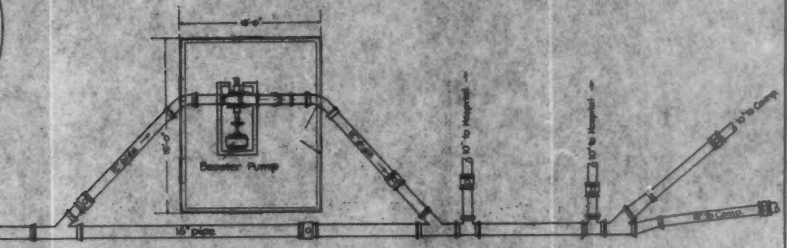
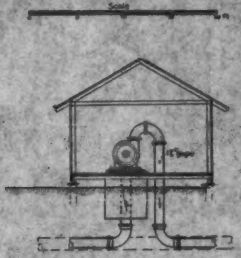


Plan and Elevation of Booster Pump and Tank Connections



s—showing relative elevations.

CAMP DEVENS, AYER, MASS
—WATER SUPPLY—
Plan showing
STORAGE TANKS AND BOOSTER PUMP
Major Edward Canfield Jr. Cons. Q.M. E.D. Barbour, Supervising Engr.
November 1917

and sharp angles. Repeated attempts in the presence of a representative of the wood-pipe manufacturer proved that it was impossible to make tight joints between the wood pipe and the standard cast-iron fittings furnished, and it was necessary to obtain special nipples — with larger bells on one end — to connect the standard fittings and the wood pipe.

Wood-stave pipe instead of cast-iron was used in the cantonment because of the lower cost (which averaged about 42 per cent. of that of iron at the time of purchase) and because it could be quickly obtained.

Does the experience with wood-stave pipe in this camp work suggest a more frequent use of this material in general water-works practice, is a question which it may not be out of place to briefly consider. Of course the answer must primarily rest on the first cost of wood as compared to iron pipe and on the probable life of wood pipe, which depends on the life of the wire bands, and this in turn on the quality of the soil in which the pipe is laid. Under normal market conditions, wood pipe will not be relatively so cheap as in 1917, and as to the life of machine-banded spirally wound pipe the answer cannot be supplied by the brief experience in the cantonments. Undoubtedly its life, as determined by that of the bands, is but a fraction of that of cast iron, and it cannot supply the assured permanence which is so important a factor in a system to be laid under the paved streets of a city or town where first cost is not the controlling element. It has greater discharge capacity than iron, and it can be more quickly and cheaply laid and repaired. Service connections are easily made by corporation cocks screwed into the wood. As indicated by results at Camp Devens, the leakage — apparently less than 100 000 gal. per day from 18 miles of mains — is not excessive. Spirally wound pipes are open to the objection that, if the wire is cut at one point, the resistance to bursting pressures for the entire length is gone; with the circular metal bands used with continuous stave pipe in larger sizes there is more metal to resist corrosion or cutting and the loss of one band does not necessarily seriously damage the pipe. Several cases of bursting pipes have occurred at Camp Devens, caused by cutting of the spiral wire by fine jet leaks and the erosion of sharp sand. As an illustration of this eroding power, a

heavy brass corporation cock screwed into the wood was worn through in less than ten days, as shown in photograph herewith presented.

At Camp Devens the pipes were laid so as to obtain a uniform cover of 5 ft. measured from the original surface of the ground. Subsequently the grading operations carried on by the soldiers in smoothing up around the barracks materially reduced this depth in a number of places, and picks were driven through the shell of the wood pipe. Such incidents, however, are of minor importance and would not occur in ordinary municipal work, and in general it may be said that the wood-stave pipe to date has proved very satisfactory.

The shorter life of wood-stave pipe as compared with cast iron and the necessarily earlier derangement of connections and street surfaces incident to replacement of the system are the important considerations in determining the choice of material rather than the failure of wood pipe to meet necessary requirements during its life — whatever this period may be.

Where first cost is not the determining factor, and in cities and towns with complicated distribution systems and paved streets, wood pipe certainly cannot be justified; but for small communities where first cost is all important, for cross-country lines when a reasonable assumption of the life of wood pipe shows its use to be economically justifiable, and for extensions to outlying districts — such as are now generally made with wrought iron of insufficient size to supply hydrants — it would seem that wood-stave pipe is worthy of more consideration than it has been accorded in the past.

The writer is likewise impressed with the possibilities of wood-stave tanks — not as a comparable alternative to steel or concrete but as a means of providing storage in cases where first cost is the all-controlling element. At Camp Devens four redwood stave tanks, 30 ft. in diameter and 20 ft. deep, of 100 000 gal. capacity each, supported on wooden towers 26 ft. high, were erected on

ground at elevation 381.0 near the southern end of the camp. The ground surface in the camp varies from elevation 250 to elevation 350, and the static pressure with tanks half full ranges from 30 lb. to 75 lb. To provide greater pressure for fire service in the higher area, a booster pumping unit — consisting of 50 h.p. motor driving direct a 2 000 g.p.m. centrifugal pump, set in a 12-in. by-pass on the 16 main leading to the tanks, and located in a small frame building at the base of the tanks, was provided. By closing a valve on the main straightway connection to the tanks, water is drawn by this booster pump from storage, and the pressure raised 24 lb.

There are three fire stations in the cantonment equipped with light motor apparatus and numerous hand hose reels on wheels housed at various points. Several fires have occurred, but these have been held to the first building attacked — a result which speaks well for the efficiency of the fire department.

Garbage.

The garbage is hauled by the military establishment to a transfer station located in the extreme western corner of the camp, and from this point is taken by a contractor, who is paid a monthly sum for the removal and sanitary disposal of all wastes at a point not less than three miles from camp. A small incinerator was constructed at the transfer station, but has been used comparatively little.

The preceding description of Camp Devens will serve to illustrate the magnitude and the diversity of the work involved in the construction of the sixteen cantonments. It is not the story of any great engineering design, but rather of how much can be accomplished in a very short time, when emergency demands, by coöperation of all those engaged in the undertaking.

It tells of unusual ability, judgment, and courage on the part of those engineers at Cantonment Division Headquarters, who planned in a few weeks the general scheme and equipment of the

cantonments and who so successfully drew the line between extravagance and the provision of the facilities necessary to the protection and physical betterment of the conscripted men. It describes the variety and bulk of the work done by the contractor through excellent organization and untiring energy, and, in its reference to operation, it calls attention to the success of Major E. W. Briggs who has had charge of the utilities.

A brief word of reference to the work of the Government engineering force in the building of the camp must be added. This force, which, including the inspectors, numbered at one time 125 men, worked at high pressure for long hours seven days each week with a spirit of service which has not been bettered by any organization.

Particularly to the men at the head of the several divisions of the engineering department is due whatever of the success at Camp Devens accrues to the Government engineering force on the ground, and the writer gratefully records his appreciation of the work done by Mr. H. J. Kellaway, general layout; Mr. E. G. Bradbury, sewerage and disposal; Mr. N. J. Neall and Mr. H. B. Abbott, electric light and power; the late Mr. W. S. Johnson, water supply; Mr. Geo. H. Wetherbee, general surveys and staking; Mr. C. W. Kimball and Mr. C. H. Bartlett, heating; Mr. W. S. Collins, roads; and by Mr. R. J. Fogg and Mr. E. K. Cortwright, inspection and reports.

THE SELECTION OF METERS.

BY CALEB MILLS SAVILLE.

[*November 13, 1918.*]

One of the ways that water departments are trying to meet and balance increased cost of labor and materials with available income is by close investigation of the necessities for purchase. In every branch of work, study is being made that will develop a proper solution of the problem of keeping service at a maximum with a minimum of expenditure. Many large ways of doing this are apparent, such as conservation of the coal pile, fewer main-pipe extensions, general installation of the meter system, and similar matters. Among the things perhaps less obviously important is the purchase of meters to meet individual requirements. The right answer to the question, what size of meter to install on a given water-service connection, is one well worth consideration.

On the one hand is the consumer, urged on by his plumber, clamoring for a large-sized meter in order to get a large flow of water with little loss of pressure. On the other hand is the water-department expenditure soaring higher and higher as the price of meters rises, due to increased cost of production.

In those cities where a service charge or a minimum rate is made dependent on the size of the service, the expense of installation is not so important as where no such charge is made.

Study of water-department reports indicates that the per capita requirement for water is increasing in this country as a legitimate result of more extended use, especially in larger places. For example, in a report to the Cambridge (Mass.) Water Board in 1903, page 18, the late Freeman C. Coffin stated, "The rate of increase in the consumption of water of 5.475 per cent. per year, or about 30 per cent. in five years, is higher than that of the increase in population, which is 13 per cent. in five years." In the

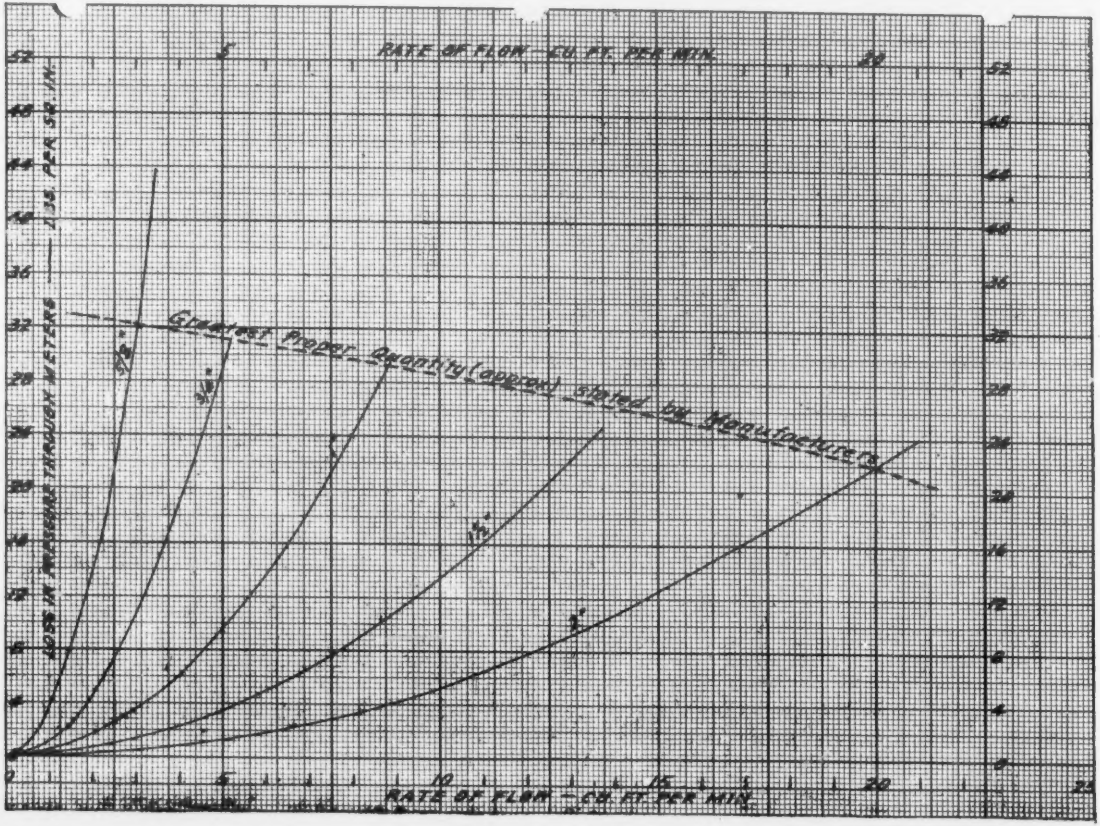


FIG. 1. AVERAGE LOSS OF HEAD IN DISK METERS OF DIFFERENT SIZES.

Freeman and Stearns report on the Baltimore Water Supply, 1910, page 24, it is stated that " there is a strong tendency manifest in nearly all the larger American cities for the per capita supply of water to increase from year to year "; and in the report on the increased water supply for the city of Providence, 1915, page 6, it is stated that " the city of Providence has for many years sold water on a metered basis, and the consumption per capita is low. It is, however, higher at the present time than it was ten or twenty years ago, the increase in per capita consumption being on an average about three quarters of a gallon daily per year." It appears, therefore, that besides the increase in total consumption to be expected as the number of people supplied becomes larger there is also a gradually increasing individual use of water. The general introduction of meters will help very materially in reducing waste, and thus aid in conserving water. The fact must not be lost sight of, however, that each place has its own characteristic, irreducible minimum, below which it is impracticable to reduce consumption and above which there is a constant tendency for proper increase.

This condition, so far as it relates to domestic use, may be due to several causes, among which are: First, plumbing installation in houses not previously having such conveniences; second, increase in the number of fixtures in houses already having plumbing fixtures; third, the installation of more modern plumbing devices which require water at high pressure and in comparatively large amounts for short periods. This last reason is of most interest in connection with the subject of this paper, because of its direct connection with the size of meter to be installed, the cost relative to the amount paid by the consumer, and the burden of the expense of installation and upkeep to the department. Advance in the plumbing art aims to control waste and to increase efficiency. The tendency in flushing is to produce a sudden deluge for a short period instead of the former lesser rate of discharge extending over a long period. For example, flushometer closets and urinals are very effective and usually economical in the total use of water. These fixtures, however, demand larger service pipes and meters than the older tank closet in order that the pressure and velocity of the flushing water may be as high as possible.

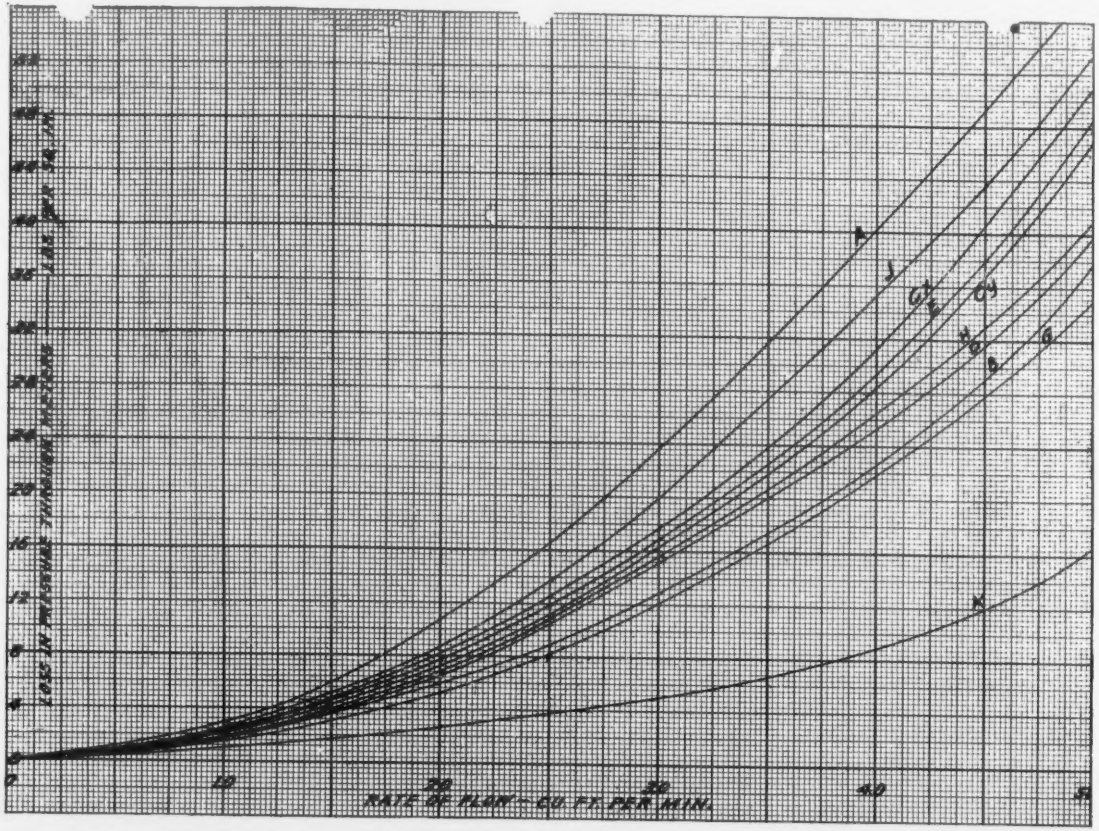


FIG. 2. LOSS OF HEAD IN ¾-IN. DISK METERS OF VARIOUS MAKES.

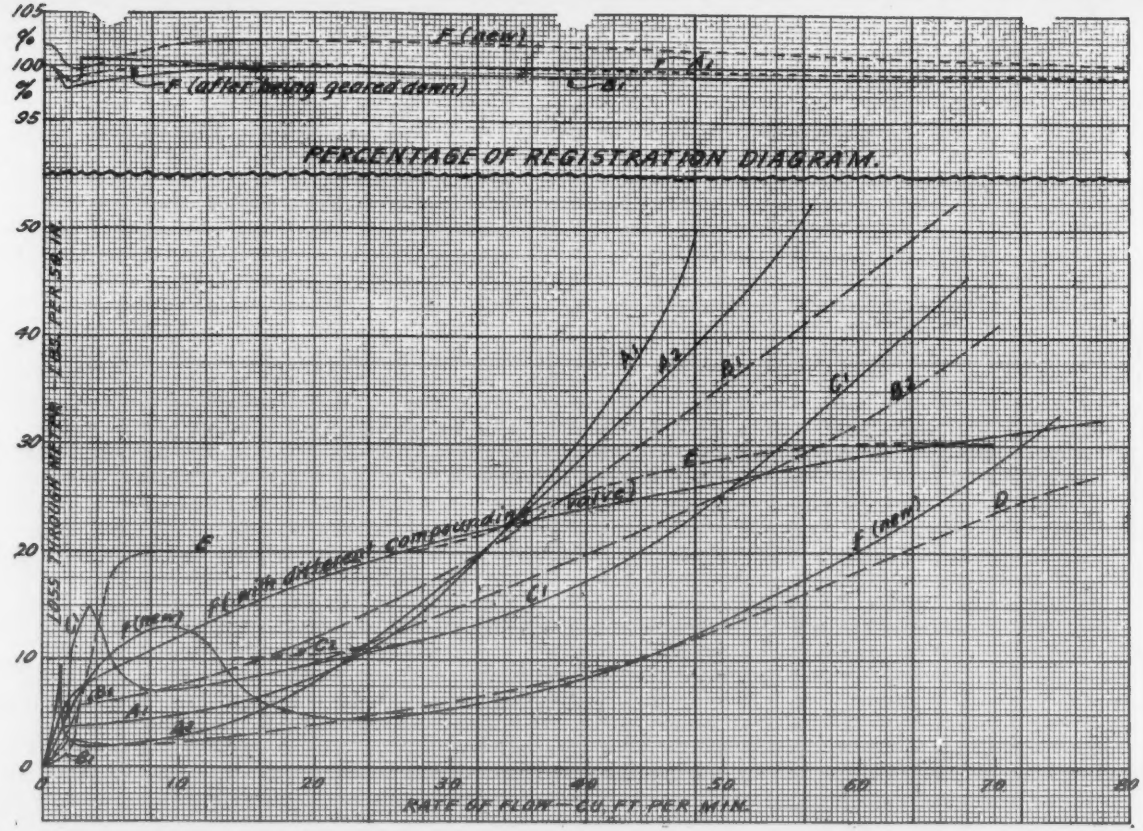


FIG. 3. LOSS OF HEAD IN 3-IN. DISK METERS OF VARIOUS MAKES.

The size of meter to be installed on a service is more dependent on the rate of flow required and the drop in pressure due to this flow in a given meter (Fig. 1) than on the actual quantity of water to be passed through it.

To meet these conditions with a view to economy as well as efficiency it is desirable to consider among other things:

1. The installation of larger service pipes instead of larger meters.
2. Proper provision in the house-piping system, to meet the demands of modern plumbing, instead of installing larger meters.
3. The selection of meters properly designed for the particular use to which they are to be put.

Requests for larger meters usually disclose that " my plumber advises me that the meter is too small and interferes with the proper operation of the new piping which has just been put in." In other cases it has been found that, although the interior piping is old and filled with rust, the owner has been advised that his trouble will be remedied if he gets a larger meter.

As to Item 2 above, it seems very probable that possibly a large-sized riser pipe acting as a house standpipe where flushometer fixtures are installed might give a better service than could be obtained by use of a larger meter.

Item 3 relates to the selection of meters, and the results of some investigations given below may be of interest if only as a suggestion of possibilities. So far as accuracy of registration and durbility goes there seems little to influence choice between any of the meters now put on the market by the half-dozen or more reputable manufacturers of water meters.

(On the diagrams referring to meter performance, letters designate different makes of meters.)

So far, however, as loss of head is concerned, meters of different makes now on the market show considerable variation.

This matter is an essential requirement, and it easily may be the case that a smaller meter of one make, and therefore of less cost, will do the work as efficiently as a larger and more costly meter of a different make. For example, the maximum proper rate of flow for 1-in. disk meters is about 8 cu. ft. per min. According to information furnished by manufacturers, one make of meter loses 19 lb. per sq. in. and another 31 lb. at this rate of discharge.

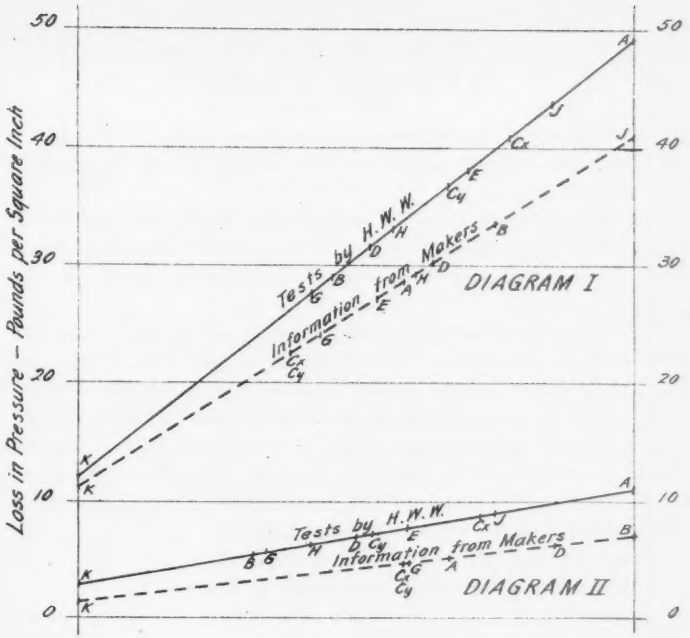


Diagram I. Rate of flow = 4.5 c.f.p.m. Diagram II. Rate of flow = 2.0 c.f.p.m.

FIG. 4. ¾-IN. DISK METERS.

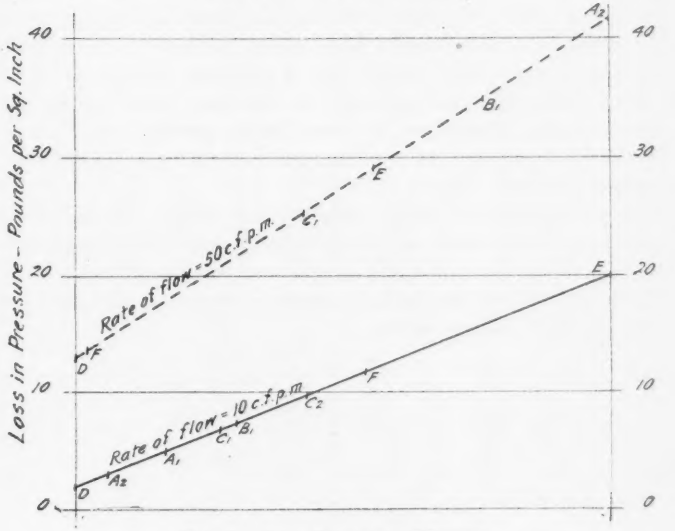


FIG. 5. 3-IN. COMPOUND METERS.

COMPARATIVE LOSS OF HEAD IN METERS OF VARIOUS MAKES.

If this flow were required with minimum loss of head, a 1-in. meter of the former make would do the work as well as a $1\frac{1}{2}$-in. meter of the other make.

As a 1-in. meter, however, costs about twenty dollars, and a $1\frac{1}{2}$-in. costs forty dollars, a saving of twenty dollars results, therefore, from careful selection among the different makes on the market.

The same reasoning applies also to choice of a compound meter. For example, suppose a flow of 48 cu. ft. per min. is required under conditions where loss of pressure is of moment. With a 3-in. meter of one make there is a loss of head of 12 lb. per sq. in., while with another make of the same size and similar flow the loss in pressure is 39 lb. per sq. in., or more than three times that of the former. In this case it is probable that if the latter make were used a 4-in. meter would be installed.

Three-in. compound meters cost about $160.00.

Four-in. compound meters cost about $260.00.

The saving by using the meters of former make would be one hundred dollars.

There are similar differences in loss of head in smaller-sized meters of different makes, and while the differences in cost between $\frac{5}{8}$-in., $\frac{3}{4}$-in., and 1-in. meters are not as great individually as in the larger sizes, nevertheless more meters of these sizes are used, and the saving to the department is apparent whether it be an accumulation of several amounts or one lump sum. Beside the money saving, consumers are much better satisfied with service that gives them the best possible results in the operation of their modern plumbing fixtures.

In many cases maximum rates of flow occur only for short periods, and this phase of the matter also has considerable bearing in deciding the economical as well as most efficient size. Some of the rates of flow met with, in ordinary practice, in Hartford are given in the following tables:

TABLE 1.

SUMMARY OF OBSERVED RATES OF USE OF WATER AT VARIOUS BUILDINGS.

Board of Water Commissioners. City of Hartford. Engineering Department. February 29, 1916. Acc. 347.

Building.	Size and Make of Meter.	Fixtures Supplied.							
		Water Closets.	Urinals.	Wash-stands.	Slop Sinks.	Bath Tubs.	Shower Baths.	Drinking Fountains.	Hydraulic Lifts.
Pilgard	2-in. Trident	27*	10	47	5	5 Seldom used.			
Pilgard Market	3-in. Trident								1
A. E. Burr School, Wethersfield Ave.	2-in. Trident	35*	22	10	3		10	11	
Hartford-Ætna National Bank	2-in. Lambert								1
New Dom Hotel	1½-in. Empire	40‡		150		12			
New Dom Hotel, (for elevator)	3-in. Crest								
Brown School, Market St.	2-in. Hersey	23‡	12	13	2			6	
20-Tenement Block, 150 Market St.	1½-in. Thomson	20§			60	20			
G. Fox & Co., Main St.	1½-in. Thomson	11‡ 12§	2	15	2			2	
Brown, Thomson & Co., Main St.	1½-in. Empire	19* 30‡	8 Seldom used.	29	22	20		2	
Empire Laundry, Sheldon St.	3-in. Hersey Compound	3*		3		8 washing machines — 150 shirt capacity 1 washing machine — 50 shirt capacity			

* Flushometer. ‡ High tank. § Low tank.

TABLE 1.—*Continued.*

Building.	Fixtures Supplied.			Max. Obs. Rates, C.F.P.M.		Meter Needed on This Supply.	Remarks.
	Elevators.	Fire Lines.	Miscellaneous.	Of at least 10 Cu. Ft. Continuously.	Of Small Quantity in Short Time.		
Pilgard			2 small boilers (return feed).	7.0	..	1 in.	Meter changed to 1½ in., 56 rooms and 150 people regularly occupying same.
Pilgard Market			1 small boiler.	3.3	20.	2 in.	Meter changed to 2 in.
A. E. Burr School, Wethersfield Ave.			2 138 H.P. boilers. 1 emerg. hyd. pump.	23.0† 12.0	20.	As installed.	About 460 pupils.
Hartford-Ætna National Bank				12.0	18.	As installed.	Fixtures are supplied from tank on roof.
New Dom Hotel				1.2	1.2	Not over ¾ in.	Meter changed to 1 in.
New Dom Hotel, (for elevator)	1 pump-operated, but direct in emergency.			30.0	..	As installed.	

Brown School, Market St.....			1 low-press boiler (return feed).	5.9	6.0	1 in.	About 500 pupils and 15 teachers, 10 rooms 31 ft. x 27 ft.
20-Tenement Block, 150 Market St....				1.2	Very slight.	Not over ¾ in.	About 110 people.
G. Fox & Co., Main St.....	1 (pump-operated)	1 ¾-in. conn. 1 1½-in. conn.	1 boiler (return feed).	3.0	4.3	As installed because of fire lines.	1,000 employees and several hundred customers per day.
Brown, Thomson & Co., Main St.....			1 soda fountain conn. 4 dentist's spittoons.	10.0	12.5	As installed.	60 two-room apartments occupied by 120 persons and department store.
Empire Laundry, Sheldon St.....			1 250 H.P. low-press. return-feed boiler.	30.0‖	30.0	As installed.	

† Swimming pool being refilled.

‖ Of at least 100 cu. ft. continuously.

Of the eleven premises noted, changes in original installations were made in four, with no apparent detriment to the service, which resulted in a saving of first cost of about one hundred dollars.

During the past two years that this investigation has been going on, the saving in new and old installations is estimated to have totaled over one thousand dollars.

The following tables give rates of water actually observed in the operation of various fixtures using water.

MEMO RE RATES OF USE OF WATER BY VARIOUS PLUMBING FIXTURES.

Fixtures.	Rate of Use. C.F.P.M.
1. Flushometer closets.	
Operating singly	4.5
Three operated in quick succession	10.0
2. Shower baths.	
10 continuously	6.0
5 continuously	4.0
10 continuously and four flushometer closets operated in quick succession	12.0
3. Urinals.	
22 operated in quick succession by two persons	5.0
4. Hydraulic lift at Hartford-Ætna National Bank	18.0
5. Hydraulic lift at Pilgard Market	20.0
6. 6-in. plunger hydraulic elevator	30.0
7. Washing machines.	
Filling two 150-shirt machines	30.0
Filling one large machine	17.0
8. Loomis and Manning filter at Hartford-Ætna National Bank	12.0
9. Filters at Alfred E. Burr School, limit of capacity	23.0
Washing filters	10.0

Very little information seems to be available in regard to rates of flow in service pipes and their duration, and no device was found on the market for getting an autographic record of the continuous use of water through service pipes and meters. Having had some experience with the Freiz Automatic Rainfall Register, the writer suggested to one of his assistants the possibility of adapting the recording mechanism of this machine to the required purpose. After some experimentation, Mr. J. E. Garratt, office engineer of the department's staff, made suitable electric

connections between the meter-counter and a rain-gage recorder, and carried out, in an able manner, the fieldwork of investigation. The apparatus is rather clumsy to take about, but it answers the purpose very well, and from its record some very interesting facts have been learned regarding use and waste of water. The apparatus is carried in a box 18 x 18 x 20 in., and including box

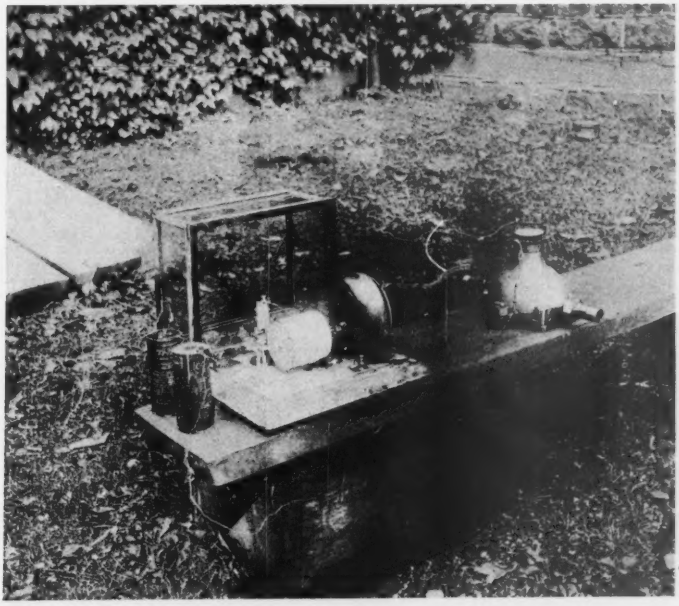


FIG. 6. RECORDING DEVICE ON ¾-IN. METER.

weighs about 40 lb. The instrument is crude and probably not extremely accurate; nevertheless the records are submitted at this time as an indication that may throw some light on the matter of water unaccounted for in systems where the services are very thoroughly metered. At any rate, the subject of meter accuracy of registration at low flows and the loss of head on high ones seems to be well worth careful study in the interests of economy, efficiency, and conservation.

The registering apparatus consists of an eight-day clock with driving mechanism for rotating a cylinder about four inches in

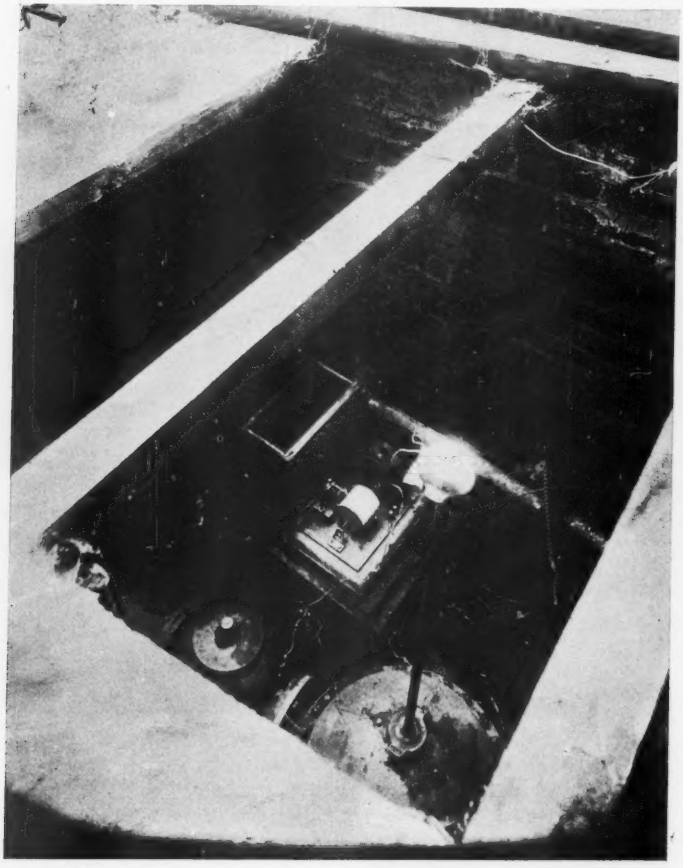


FIG. 7. RECORDING DEVICE ON LARGE METER IN PIT.

diameter, around which the chart is wrapped in one fold. A very ingenious device carrying the recording pen is operated by electric contact at each tip of the bucket in the rain gage or each revolu-

tion of a counter in the case of a meter. The driving mechanism is so constructed that the drum makes an entire revolution every six hours, and the feed is so regulated that the pen describes a spiral on the rotating chart, the lines of which are about one quarter inch apart, and thus avoid being superimposed. Rate of flow is indicated by the number of contacts registered by the pen on the chart, Fig. 8. Each of these contact marks is in the form of a step, the characteristic trace being five steps down and five steps up. From top to top of any series of steps there are 10 contacts. The chart is marked vertically in five-minute lines. At a glance, therefore, it is possible to read the number of steps or revolutions in any given period, and also observe the time at which the water was drawn. One defect in the registering device is its inability to record sudden flows of less than 1 cu. ft., although the total quantity is registered. For an example of the use of the recorder: on the 576 Farmington Avenue chart the record began about 10.40 A.M., Tuesday, June 12, and the preparations for luncheon are clearly shown. At 11.47 a draft of about 2.5 cu. ft. per min.; at 12 noon another draft of a similar amount. Throughout the afternoon there was some use up to about 3 P.M., then a period of comparative rest until about 6 P.M., when for two hours during the dinner period there was intermittent use. At about 10.25 a use of about 5 cu. ft. in four minutes indicates possibly the filling of a bathtub. From this time until 6.17 the next morning there was no flow, indicating either remarkably tight plumbing or a meter which failed to register small flows. From 7.10 to 8.50 a considerable use of water is noted, used probably for bathing and for the family breakfast. The maximum use in the house on this day was 1.25 cu. ft. per min., and it is noted that the recording mechanism checked the meter reading of 68 cu. ft. for the twenty-four hours' use. For the week that this house was under observation the following consumption and maximum rates were shown.

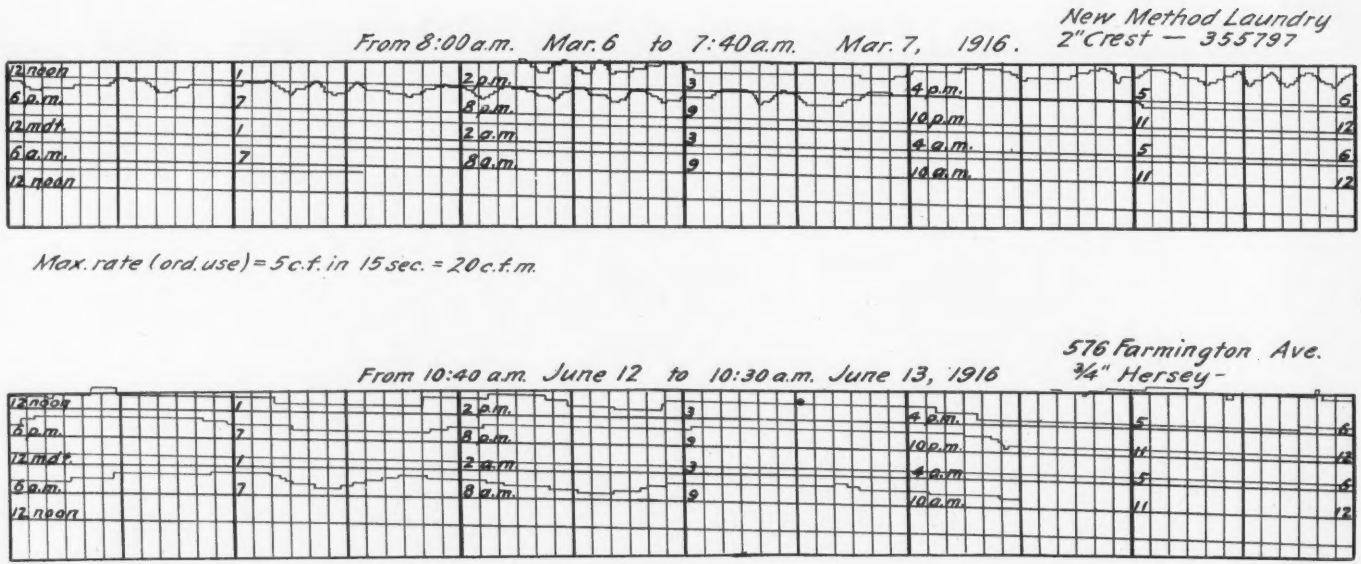


FIG. 8. TYPICAL CHART FROM RECORDING DEVICE.

In the following table, made up from the chart record of the same house, June 5 and 6, many interesting features appear which seem to be characteristic of this class of service. The rates of flow of this house and also from an apartment house for a 24-hour run made up from the autographic record are shown on Fig. 9.

TABLE 2.

	Consumption.		Max. Rate per Min.	Duration of Max. Rate.
	Cu. Ft.	Gal. per Cap.	Cu. Ft.	Min.
Thursday, June 5.....	65	81	1.00	3.0
Friday, June 6.....	24	36	1.65	2.0
Saturday, June 7.....	46	58	1.33	1.5
Sunday, June 8.....	34	42	Pen out of order	...
Monday, June 9.....	52	64	2.20	2.0
Tuesday, June 10.....	43	53	1.30	2.5
Wednesday, June 11...	68	85	1.00	2.0
Thursday, June 12.....	68	85	1.25	4.0

From this study it appears that probably in the first house (Fig. 1) at least 11 per cent. of the water delivered was unrecorded by the meter, while for the entire twenty-four hours, except for three minutes at about 10.43 A.M., the rate of draft was below 2 gal. per minute. The upper figure (Fig. 1) on the diagram shows these rates graphically for the single dwelling, while the lower figure (Fig 2) shows the rates for the apartment house mentioned below. The most interesting matter in relation to both of these diagrams is perhaps a condition which is clearly brought out, namely, that for most of the time the flow through the meter lies in the zone between the 90 per cent. and 98 per cent. accuracy ordinarily guaranteed from disk meters. If this condition is characteristic of meter performance it at least offers an explanation for accounting for some of the hitherto unaccounted-for water reported from fully metered water departments, ordinary rates appearing to occur on that portion of the scale where the registration is the least accurate in the meters used.

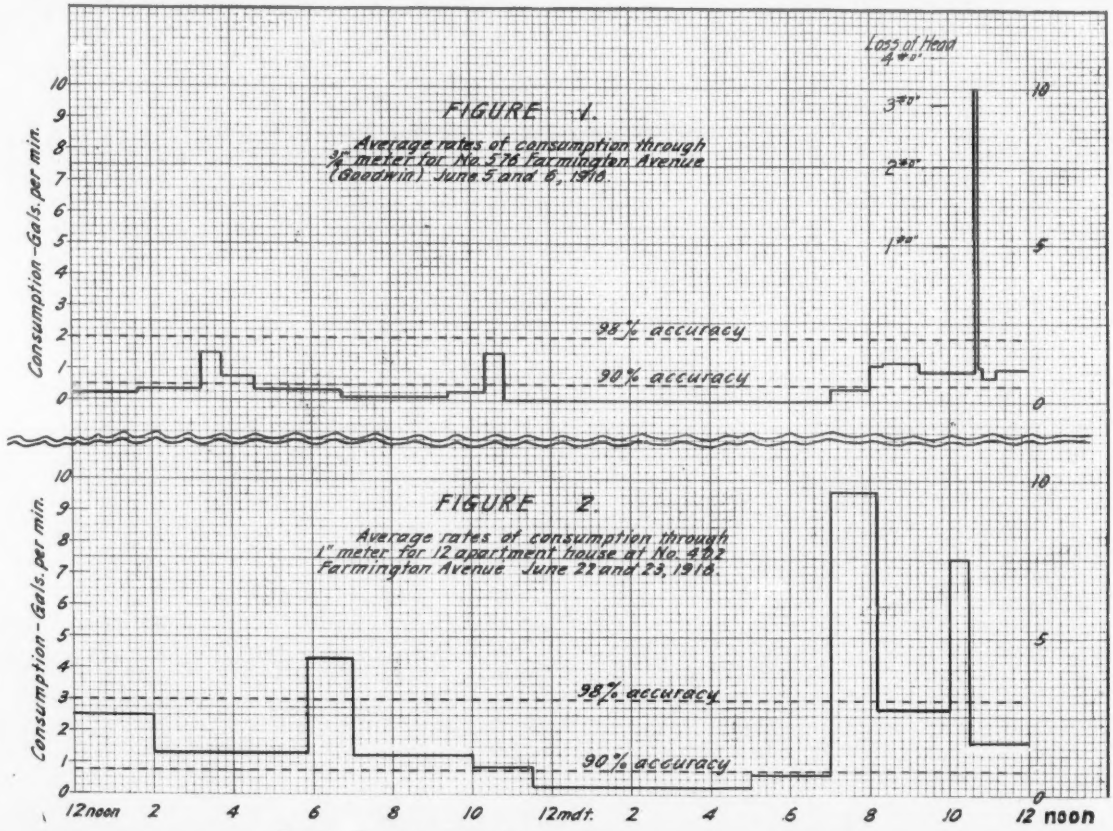


FIG. 9. DIAGRAM GIVING RATES OF FLOW AS INDICATED BY CHARTS.

TABLE 3.

RECORD FROM METER ON NO. 576 FARMINGTON AVENUE. ¾-IN. METER. JUNE 5 AND 6, 1916.

1	2	3	4	5	6	7	8
Time.	Elapsed Time.	Observed Quantity.		Rate	Duration of Flow.	Probable Accuracy of Measurement Based on Meter Mfrs' Schedule.	Probable Actual Delivery of Water.
	Min.	Cu. Ft.	Gal.	Gal. per Min.	Per Cent. of 24 Hr.		Gallons.
10.50–11.10	20	2	15.	0.75	1.4	0.91	16.5
12 N.	50	7	52.5	1.05	3.5	.93	56.5
1.40	100	3	22.5	.23	6.9	.80	28.1
3.15	95	4	30.	.32	6.6	.85	35.3
3.45	30	6	45.	1.50	2.1	.96	46.8
4.35	50	5	37.5	.75	3.5	.91	41.3
6.45	130	5	37.5	.29	9.0	.80	47.0
9.25	160	2	15.0	.10	11.1	.60	25.0
10.20	55	2	15.0	.27	3.8	.80	18.7
10.50	30	6	45.0	1.50	2.1	.95	47.3
7 A.M.	490	0	0.	.00	34.0	...	....
8.00	60	3	22.5	.38	4.2	.85	26.5
8.20	20	3	22.5	1.13	1.4	.94	23.9
9.15	55	9	67.5	1.22	3.8	.94	71.8
10.40	85	6	45.0	.53	5.9	.90	50.0
10.43	3	4	30.0	10.00	.2	1.00	30.0
10.50	7	1	7.5	1.07	.5	.93	8.1
	1 440	68	510.0	.36	100.0	0.89	572.8

Six persons, 86 gal. per capita.

Probable amount.....572.8 gal. in 24 hr.
Recorded amount.....510.0 gal. in 24 hr.

Unrecorded..... 62.8 gal. in 24 hr.

11 per cent. not recorded.

Column 7 of the table was obtained by straight-line proportion between the low rate giving 98 per cent. and the rate giving 90 per cent. for the given sized meter based on the schedule of the Meter Manufacturers' Exchange. From present information available it appears that the percentage of registration between the given limits varies as a curve instead of as a straight line, and the actual at present registration is less than that used in this paper.

The house under consideration is a one-family dwelling in the best residential part of Hartford, built perhaps twelve or fifteen

years ago. It is generally occupied by six persons and in the year 1916 had a total use of 16 400 cu. ft., equivalent to an average per capita consumption of 56 gal. per day. The water pressure here is about 70 lb. The premises were originally served through a $\frac{5}{8}$-in. meter. A complaint was made of inadequate service, and a new 1-in. service pipe was installed by the owner. A request for a 1-in. meter was made on advice of the plumber. A $\frac{3}{4}$-in. meter was attached, and the owner was rather put out at first because the larger-sized meter was not installed. The water fixtures in this house comprised:

Three set tubs in laundry, with hot and cold water.
One sink in laundry, with hot and cold water.
One sink in kitchen, with hot and cold water.
Two water-closets, tank type.
Four washstands, with hot and cold water.
One bathtub, with hot and cold water.
Two $\frac{3}{4}$-in. hose bibs in garage.
One $\frac{3}{4}$-in. sill cock.

In investigating this house the following report was made: "With two cold-water faucets open in the basement laundry and one hose connection in the garage, only a fair flow of water was obtained in the bathroom faucets on the second floor. With this demand the $\frac{5}{8}$-in. meter showed a rate of 2.25 cu. ft. per minute, which is in excess of the 'maximum proper rate of flow.' A $\frac{3}{4}$-in. meter is recommended." This installation has been perfectly satisfactory.

In one of the highest class apartment houses recently built, (Cut 9, Fig. 2), containing 12 separate suites and having an average population of 40, the use of water in 1916 was at a rate of 72 gal. per capita. The static pressure in the street main is about 70 lb. per sq. in. There is a 1-in. meter on the premises, which is giving satisfaction.

This house was fitted with the most modern plumbing throughout, and has a garage attached.

The following table shows average rates from noon on Wednesday, June 22, 1916, together with computations indicating conditions which exist relative to recorded use of water.

TABLE 4.

1	2	3	4	5	6	7	8
Time.	Elapsed Time.	Observed Quantity.		Equiv. Rate.	Duration of Flow.	Probable Accuracy of Measurement Based on Meter Mfrs.' Schedule.	Probable Actual Delivery of Water.
	Min.	Cu. Ft.	Gal.	Gal. per Min.	Per Cent. of 24 Hr.		Cu. Ft.
12 N.-2 P.M.	120	40*	299	2.5	8.3	97%*	41.4
2.00–5.50	230	40	299	1.3	16.0	92	43.5
5.50–7.00	70	40*	299	4.3	4.9	100*	40.0
7.00–10.00	180	30	224	1.24	12.5	92	32.6
10.00–11.30	90	10	75	0.83	6.3	90	11.1
11.30-5 A.M.	330	10	75	0.23	22.9	80†	12.5
5.00–7.00	120	10	75	0.62	8.3	90	11.1
7.00–8.10	70	90*	673	9.6	4.9	100*	90.0
8.10–10.00	110	40*	299	2.7	7.5	99*	40.5
10.00–10.30	30	30*	224	7.5	2.1	100*	30.0
10.30–Noon	90	20	150	1.67	6.3	93	21.5
	1 440	360	2 692	1.87	100.0	96.3	374.2

* Assumed as accurate. † Estimated accuracy.

According to this record there was comparatively accurate registration of the amount of water supplied for less than seven hours. During the remainder of the twenty-four hours the registered amount of water seems to have been at least from 8 per cent. to 10 per cent. less than that actually delivered, and during five and one-half hours probably only a very small proportion was recorded. Applying the probable per cent. registration given in Column 6 to the amount delivered in Column 3, Column 7 results in a total discrepancy of about 14 cu. ft., or 3.7 per cent. unaccounted for in this service. At 12c. per 100 cu. ft., this condition means a loss of $6.13 per year to the department.

Six dollars per year is about the amount paid on many services supplying small families on which $\frac{5}{8}$-in. meters are installed at a present cost of $10. There seems to be no logical reason why it is not as desirable to receive pay for all water passing through the service, whether it be a large or small consumer. If a more sensitive measuring device than those at present in use will necessitate paying a higher price than the present type of meter costs,

water departments can well afford to pay the additional cost if they can be assured of more accurate results than seem possible with the present meter.

The Brown School chart (not shown) shows conditions as to use of water in a large public-school building relative to the normal rates of use of water there.

Maximum observed rate of use of at least 10 cu. ft. of water continuously as produced by normal use	5.9 cu. ft. per min.
Maximum observed rate of short duration and of small quantity (at recess time)	6.0 cu. ft. per min.

The fixtures supplied by this meter are as follows:

Water-closets (high tank, flushed by seat)	23
Urinals (automatically flushed from three tanks of same size as for closets)	12
Washstands	13
Drinking fountains	6
Faucets (equivalent to slop sink)	2
Boiler for heating (low pressure, return feed)	1

Five hundred pupils and 15 teachers use these fixtures.

There are ten rooms, 31 ft. by 27 ft., in this building.

The 2-in. meter originally in this building was capable of properly passing 20 cu. ft. of water per minute. The maximum observed rate under natural conditions of use was but 6 cu. ft. per min.

This meter was replaced with a 1-in. meter at a saving of $42 on present prices. In addition to this, the accuracy of registration was increased by use of the smaller meter and the amount of unpaid-for water reduced.

A chart from a laundry shows conditions where large quantities of water are used continuously during the day and thus indicating the type of meter which should be used under similar conditions.

Here is a 2-in. service, about 50 ft. long, from the main to the meter. Inside, about 75 ft. of 2-in. pipe carried the water from the meter to the principal source of use.

The following information was obtained relative to the usual rates of use of water:

Maximum observed rate of use of at least 10 cu. ft. of water continuously as produced by normal use	20 cu. ft. per min.
Maximum observed rate of short duration, 5 cu. ft. in 15 seconds	20 cu. ft. per min.
Rate produced when filling one large washing machine	17 cu. ft. per min.
Rate produced by opening two or more inlets to large washing machines	20 cu. ft. per min.

The limit of the system is apparently 20 cu. ft. per min.

The fixtures supplied with water at this laundry are as follows:

Washing machines — very large	1
large	5
small	3
Water-closets, high tank	3
low tank	1
Sinks	2
Set tubs	7
Faucets in barn (6 horses stabled in barn)	2
Boiler, 100 h.p. low pressure, return feed	1

There are 60 employees at this establishment.

The following information was obtained relative to the amount of water used in laundry washings:

Number of fillings of washing machine for flat work	5
Number of fillings of washing machine for starch work, such as collars, cuffs, dress shirts, etc.	8
Cubic feet of water used for 50 washing machine loads requiring 265 fillings	3 890
Cubic feet of water per filling of washing machine	14.7
Cubic feet of water per load in washing machine	78

The 2-in. Trident Crest meter on this laundry is capable of properly passing 33 cu. ft. of water per minute. The maximum possible amount which the piping system is capable of delivering is apparently 20 cu. ft. per min. The meter is able to handle this quantity easily. A service for any similar installation with more adequate piping should be at least 3-in.

The records of the use of water in both the private house and the apartments are representative of conditions in a large number of houses in Hartford and elsewhere. Probably the demand in these houses is much larger than in many others, yet even in these

examples it appears that the maximum rates observed are only just within the limits of the 4 per cent. accuracy which is the best the meter manufacturers are willing to guarantee. The bulk of the use of water in private houses of the class here noted is apparently at a rate of from 0.5 to 1.0 gal. per minute. The accuracy of registration for this rate on the basis of the meter manufacturer's schedule for the size of meter installed is probably about 92 per cent., that is, on such services in ordinary use about 8 per cent. of the water used is not accounted for. A $\frac{5}{8}$-in. meter would account for a much greater proportion of the water drawn. On the other hand, its use would be totally unsatisfactory to the consumer because it would cut down the pressure when large quantities of water were required and so interfere with the efficient operation of the plumbing.

All that has been said regarding the accuracy of registration of water for the private house applies with equal force to the apartment house. In this case with the 1-in. meter a rate of flow of $\frac{3}{4}$ gal. per min. only is guaranteed for registration within 90 per cent. accuracy, and flows of from 1 to 1.5 gal. per min. would probably be recorded within from 92 to 95 per cent. of the true amount. An inspection of the chart for this service indicates that for at least during eighteen out of the twenty-four hours the demand for water was less than 1.5 gal. per min., and at rates which from 90 to 95 per cent. only, was recorded for payment to the department.

In his report in water waste, Mr. Frank A. Barbour (JOURNAL N. E. W. W. A., Vol. XXX, 1916, p. 440) states: "Even in fully metered systems about 20 per cent. of the total water supply is unaccounted for by sale to consumers." And in their report on Water Rates (JOURNAL N. E. W. W. A., Vol. XXX, 1916, p. 459) the committee stated "its belief that under-registration of meters formed a substantial part of the total loss in systems where the pipes and service pipes have been carefully and systematically followed up for leakage. . . ."

The conditions shown above and the expressed opinions of specialists in water consumption matters indicates plainly that the time has come when more attention should be given to the design of meters, with a view to greater accuracy on low flows and

TABLE 5.

MAXIMUM PROPER RATE OF FLOW AND LOST HEAD THROUGH DISK METERS, TOGETHER WITH THE LENGTH OF STRAIGHT PIPE WHICH GIVES THE SAME LOST HEAD AT THIS RATE.

(Based on Williams and Hazen Tables.)

Size of Meter.	Ordinary Maximum Rate of Flow (approx.)		Head Lost at This Rate.		Approximate Length in Feet of Straight Pipe to Give Same Loss of Head as Meter.							
In.	Cu. Ft. per Min.	Gal. per Min.	Lb.	Ft.	¾ in.	1 in.	1¼ in.	2 in.	3 in.	4 in.	6 in.	8 in.
⅝	2.2	16	20	46	50	165						
¾	3.4	25	20	46	20	70	600					
1	6.7	50	20	46		20	160	450				
1½	11.2	85	20	46			60	170	1 250			
2	17	130	20	46			30	80	570	2 300		
3	45	335	20	46				15	100	400	2 900	
4	70	525	20	46					45	175	1 200	
6	120	900	20	46						65	460	1 900

TABLE 6.

INFORMATION SUBMITTED WITH PROPOSALS FOR FURNISHING WATER METERS TO THE BOARD OF WATER COMMISSIONERS, CITY OF HARTFORD.

Bids opened January 24, 1916.

Number of Meters to be furnished: 300–⅝″, 225–¾″, 75–1″, 15–1½″ and 10–2″.

Bidder.		Hersey Mfg. Co.	Pittsburgh Meter Co.	Hersey Mfg. Co.	H. R. Worthington.		Union Water Meter Co.	Pittsburgh Meter Co.	Neptune Meter Co.	Thomson Meter Co.	National Meter Co.
Name of Meter.		Model F.	Keystone Type W.	Model FF.	Model G.	Model D.	King.	Keystone Type DC.	Trident.	Lambert.	Nash.
(a.) Price,	⅝″ complete,	$5.60	$5.60	$6.00	$5.50	$6.00	$6.97	$6.80	$8.00	$8.00	$9.00
	⅝″ by parts,	7.52	8.02	7.52	6.41	9.16	9.40	9.01	11.55	9.36	9.63
	¾″ complete,	8.00	8.40	8.60	9.50	10.00	9.40	10.20	12.00	12.00	13.50
	¾″ by parts,	10.40	10.46	10.40	10.14	12.42	13.67	12.75	15.25	12.30	13.395
	1″ complete,	11.20	11.20	12.00	12.50	13.00	12.90	13.60	16.00	16.00	18.00
	1″ by parts,	13.58	15.25	13.58	13.77	16.72	18.20	18.33	22.50	16.73	19.48
	1½″ complete,	‡24.00		‡24.00	‡26.00	26.00	24.98	25.50	30.00	30.00	35.00
	1½″ by parts,	‡26.18		‡26.18	‡*29.94	*29.94	42.30	40.85	41.10	27.96	31.90
	2″ complete,	‡40.00		‡40.00	‡45.00	45.00	37.97	42.50	50.00	50.00	55.00
	2″ by parts,	‡42.01		‡42.01	‡46.78	46.78	57.30	59.64	53.60	46.34	55.38
(b.) Number of oscillations of disk to register l. c. f. of water.	⅝″ Meter,	430.	357.	300.	296.	296.	273.	289.	362.25	295.	268.
	¾″ Meter,	220.	194.	163.	161.	161.	139.	159.	246.5	155.	199.
	1″ Meter,	114.	100.	80.	97.8	97.8	73.	79.8	92.55	75.	81.
	1½″ Meter,	‡37.		‡37.	‡37.5	37.5	35.	37.9	35.4	36.	59.
	2″ Meter,	‡24.		‡24.	‡22.5	22.5	19.	19.5	19.2	19.	28.
(c.) Weight in pounds.	⅝″ Meter,	8.	7.5	9.	7.5	9.	9.75	10.5	12.5	10.25	13.5
	¾″ Meter,	12.	13.5	13.	10.5	14.	13.2	14.25	15.0	12.50	18.0
	1″ Meter,	16.	18.33	18.	15.5	17.	19.3	21.5	26.0	18.25	28.0
	1½″ Meter,	‡34.		‡34.	‡33.0	33.	39.2	41.0	39.0	31.75	55.0
	2″ Meter,	‡53.		‡53.	‡60.0	60.	50.0	62.0	50.0	53.00	80.0
(d.) Maximum proper rate of flow cu. ft. per min.	⅝″ Meter,	3.	3.	3.	2.5	2.5	3.3	3.33	3.0	2.0	2.
	¾″ Meter,	5.	4.	5.	4.0	4.0	4.8	4.66	5.4	4.0	4.
	1″ Meter,	9.	8.	9.	7.0	7.0	8.5	8.66	9.0	8.0	8.
	1½″ Meter,	‡14.		‡14.	‡12.0	12.0	13.25	14.0	13.0	12.0	12.
	2″ Meter,	‡25.		‡25.	‡20.0	20.0	20.25	22.0	22.0	25.0	20.0

(e.) Guaranteed accuracy.	¾″ Meter,	98.0%	98.0%	98.0%	99.0%	99.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	1″ Meter,	98.0%	98.0%	98.0%	99.0%	99.0%	98.0%	98.0%	98.0%	98.0%	98.0%
1. At maximum proper rate of flow.	1½″ Meter,	98.0%	98.0%	98.0%	99.0%	99.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	2″ Meter,	‡98.0%		‡98.0%	‡99.0%	99.0%	98.0%	98.0%	98.0%	98.0%	98.0%
		‡98.0%		‡98.0%	‡99.0%	99.0%	98.0%	98.0%	98.0%	98.0%	98.0%
2. At following intermediate rates, cu. ft. per min.	¾″ Meter, 0.06,	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	1″ Meter, 0.11,	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	1½″ Meter, 0.17,	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	2″ Meter, 0.30,	‡98.0%		‡98.0%	‡98.0%	98.0%	98.0%	98.0%	98.0%	98.0%	98.0%
	Meter, 0.60,	‡98.0%		‡98.0%	‡98.0%	98.0%	98 0%	98.0%	98.0%	98.0%	98.0%
3. At minimum rate of flow, cu. ft. per min.	¾″ Meter, 0.022,	90.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%
	1″ Meter, 0.044,	90.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%
	1½″ Meter, 0.066,	90.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%
	2″ Meter, 0.13,	‡90.0%		‡90.0%	‡95.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%
	Meter, 0.27,	‡90.0%		‡90.0%	‡95.0%	95.0%	90.0%	95.0%	95.0%	90.0%	95.0%
(f.) Drop in pressure with maximum rate of flow with strainer in place in meter in lb. per sq. in.	¾″ Meter,	29.	30.	29.	6.	17.	24.	25.	12.5	†7.5	14.
	1″ Meter,	29.	30.	29.	18.	24.	24.	27.	16.0	22.5	18.
	1½″ Meter,	29.	30.	29.	20.	25.	24.	32.	25.0	30.0	24.
	2″ Meter,	‡25.		‡25.	‡20.	20.	25.5	26.	16.0	12.5	19.
		‡25.		‡25.	‡22.	22.	26.	28.	11.0	27.5	20.

‡ Model D. † Probably without strainer. With strainer, 14 to 16 lb. per sq. in. by test.
* This figure given in bid. Total apparently should be $27.98.

STATED REQUIREMENTS IN SPECIFICATIONS.

	¾ in.	¾ in.	1 in.	1½ in.	2 in.
Maximum proper rate of flow at least (cu. ft. per min.),	2.	4.	8	13.3	20.
Accuracy of registration at (1) maximum proper rate, (2) at stated inter. rate,	For all sizes,			98–100%	
At (3) minimum rate stated above,	For all sizes,			90–100%	
Drop in pressure at above stated maximum proper rate,	For all sizes,			not more than 30 lb. per sq. in.	

TABLE 7.

Average Conditions Applicable to Disk Meters.

Size. Inches.	Maximum Proper Rate for Use. (Approx.)		Average Pressure Loss.		Limits of Accuracy Proposed by Meter Mfrs.' Exchange.		Ratio Carrying Capacity with Given Loss of Pressure.	Present Prices.	Approximate Delivery with Stated Loss of Pressure.		
	Permissible.	Ordinary.	Permissible.	Ordinary.	98 to 102 Per Cent.	90 Per Cent.			Gal. per Min. above. Cu. Ft. per Min. below. Loss Lb. per Sq. In.		
	Gal. per Min. above. Cu. Ft. per Min. below.		Lb. Sq. In.		Gal. per Min.				5 Lb.	10 Lb.	15 Lb.
⅝	22.5	16			20 to 1	0.25	1.0	$10	8.4	11.8	14.5
	(3)	(2.2)	36	20					(1.1)	(1.6)	(1.9)
¾	33.8	25			35 to 2	0.50	1.5	$15	12.6	17.8	21.8
	(4.5)	(3.4)	36	20					(1.68)	(2.37)	(2.91)
1	67.5	50			60 to 3	0.75	3.0	$30	25.2	35.5	43.6
	(9)	(6.7)	36	20					(3.36)	(4.74)	(5.82)
1½	112.5	85			100 to 5	1.50	5.0	$40	42	59	73
	(15)	(11.2)	36	20					(5.6)	(7.90)	(9.7)
2	168.5	130			160 to 8	2.00	7.5	$62	63	89	109
	(22.5)	(17)	36	20					(8.4)	(11.85)	(14.5)

less friction on the high ones, even if the cost of the meter is increased thereby. Also it appears that too much "tolerance" in meter design cannot be tolerated by water departments, especially by those where water is filtered or pumped and every unnecessary gallon sent to the distribution system means not only waste of water but increase in the annual cost for maintenance and operation. The compound meter was a long stride toward more accurate accountability on those services where there are intermittent calls for large quantities of water. What now seems to be needed is re-design of present meter mechanism or a new water-measuring device for use on services, now covered by disk meters 2-in. and less in size, which will give more accurate measurement of small flows with less loss of head at the larger rates.

In the prospectus issued by most meter manufacturers is a table stating the maximum proper rate of flow to which the particular sized meter is adapted. Tests of various meters of the given sizes show that the loss of pressure at this rate is usually considerably more than can be spared in ordinary practice, and, in addition, the rate at which the disk must oscillate with this flow is a menace to its safety. On this account the following rates are suggested as a safe maximum, which under ordinary conditions it is inadvisable to exceed; 20 lb. per sq. in. loss has been taken as the maximum allowable loss in this table. Based on the quantity of water which can be obtained through the meter with this loss of head a table (Table 5) has been prepared giving the length of straight pipe of several sizes having an equivalent loss of head.

Table 6 gives information submitted with proposal for furnishing water meters to the Board of Water Commissioners, Hartford, in 1916. A study of the items in this table shows the wide variation in details of the meters offered by different makers. In addition to this, actual tests, with sample meters submitted with the bids, showed that some of the data given varied considerably from the facts.

For the purpose of having data at hand concerning losses in other portions of the service besides the meter, tests were made of losses of head in various fittings used in connecting up service

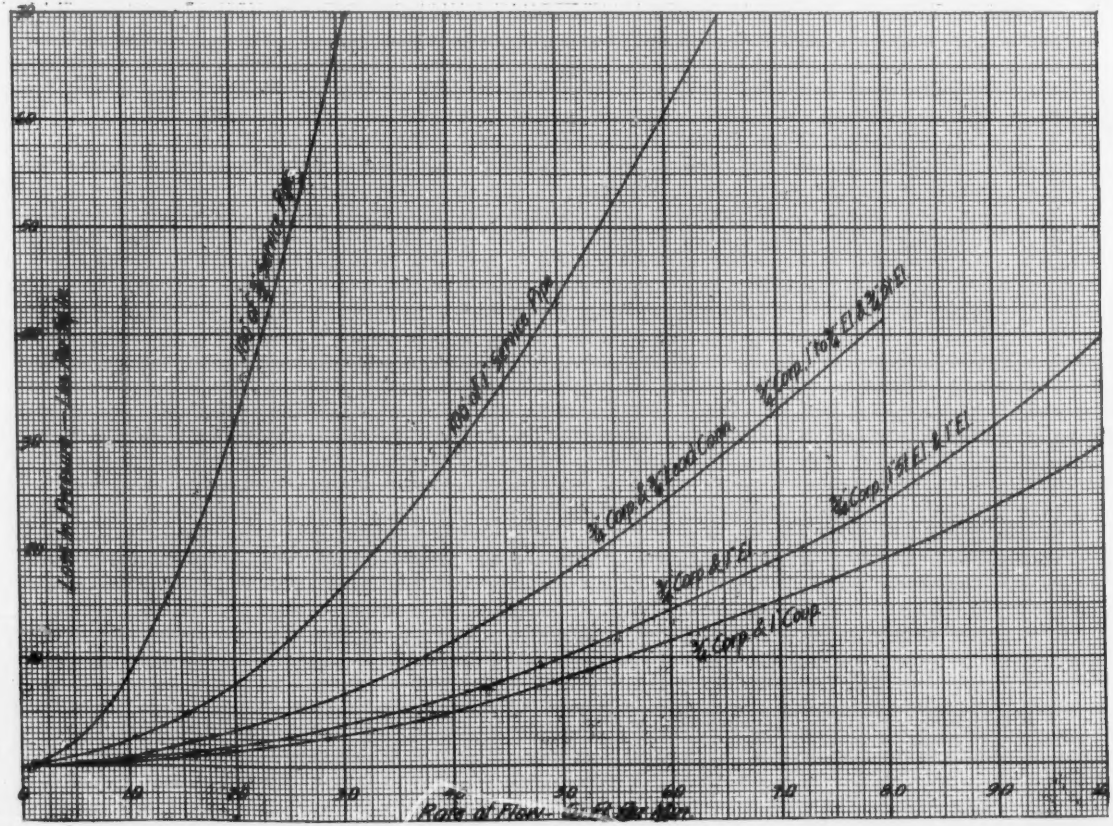


FIG. 10. LOSS OF HEAD IN ¾-IN. SERVICE PIPE AND FITTINGS.

pipes. These tests were carefully conducted, but no attempt was made to get results under theoretical conditions; the intent was to obtain information applicable to ordinary trench work of good character. For the purpose, a length of 6-in. cast-iron pipe was tapped by the regular service-pipe gang and a service installed by them in the ordinary way. The ends of the 6-in. pipe were capped and the pipe filled and kept under pressure by means of two lines of $2\frac{1}{2}$-in. fire hose.

Cut 10 gives losses of pressure through $\frac{3}{4}$- and 1-in. service pipe and $\frac{3}{4}$-in. corporations with various connections.

Cut 11 gives losses of pressure through 1- and $1\frac{1}{2}$-in. service pipe and 1-in. corporations with various connections.

Table 7 puts in tabular form some information applicable to average conditions and is intended only for use under ordinary or average conditions.

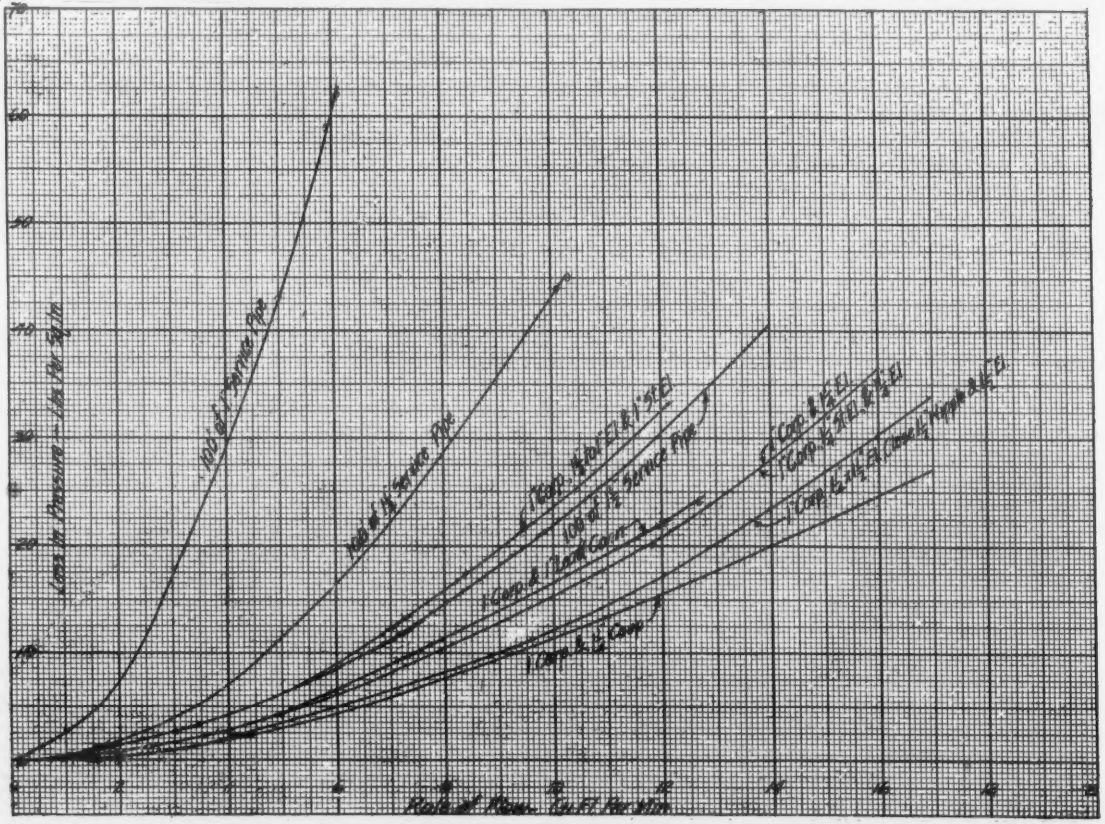

Loss in Pressure—Lbs. per Sq. In.
100 ft. 1" Service Pipe
100 ft. ¾" Service Pipe
100 ft. 1" Service Pipe
1 Corp. & 2 Curb Cocks
100 ft. ¾" Service Pipe
1 Corp. & 2 Curb Cocks
1 Corp. & 2 Curb
Rate of Flow, Cu. Ft. per Min.

FIG. 11. LOSS OF HEAD IN 1-IN. AND ¾-IN. SERVICE PIPE AND FITTINGS.

Discussion.

Vice-President Killam. Speaking of the per cent. of water unaccounted for by meters, Mr. Dunn some years ago took a system which was absolutely porous, cement-lined pipe, and has brought the system up so that it is now in excellent condition, and the per cent. of water accounted for is remarkable. We should like to hear from him.

Mr. Lewis R. Dunn. Mr. President, I am willing to answer any questions which any gentleman may wish to ask me. I may simply say that when I took the system I was with the Goodhue & Birney Company. In about 1900 the town of Revere bought the Revere end of the system, and that left the town of Winthrop on the company's hands. I had been with them since 1890, and they sent me over to Winthrop to run that end of it. Mr. Goodhue wasn't much in favor of meters, and when I took charge of the plant, with a population of something like eight or nine thousand people, there was a consumption of about 140 gal. per capita. Now we have, with all the soldiers at the fort, somewhere about fifteen or sixteen thousand people, and I think the consumption last month was 52 gal. The reduction has all been brought about by meters. The main-pipe work has been thoroughly done, and we have, perhaps, paid as much for repairs as any town or city in the Metropolitan District; but the fact remains that there haven't been but three main-pipe leaks in three years. We have had a little trouble with having to re-pack the tops of our valves, but that has been very small; and I give the whole credit for the water that has been saved, to the town of Winthrop, to the thorough installation of meters.

Vice-President Killam. Can you give us the percentage accounted for last year and the year before?

Mr. Dunn. I think it has been accounted for within less than three per cent. for three years running.

QUARTERMASTER TERMINAL REQUIRED FOR WAR WORK.

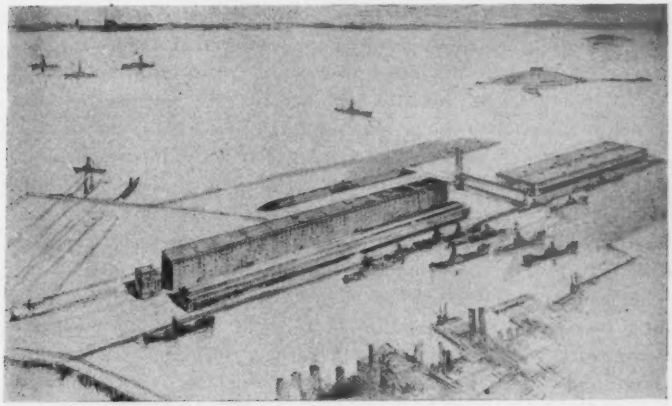
BY MAJOR CHARLES R. GOW, CONSTRUCTING QUARTERMASTER AT BOSTON.

[*September 11, 1918.*]

Mr. President and Fellow-Members, — From the day when this Government entered into hostilities with Germany it became apparent to all of us that we were confronted with a very difficult and serious problem in the organization and equipment of the millions of troops required, and their transportation across three thousand miles of sea to the fighting front on the other side. I think that probably a great many of you have failed to realize the magnitude of the problem which still confronts the Government once the troops are safely transported across the sea, in maintaining and supplying them. It is estimated by competent military authorities, based on the experience of the belligerents so far, that there are required on the average 50 lb. of supplies per man per day. On this basis, with approximately two million troops, that we have or will shortly have on the other side, there is required a daily shipment of approximately 50 000 tons of supplies from these shores, and the ultimate requirement, with the anticipated army of five millions, will be a shipment daily of 125 000 tons.

Now, to make these figures impressive it is necessary to analyze them. For instance, a 40-car train, which I believe is about the maximum that we haul here in New England, will carry on the average about 1 000 tons. This means that the ultimate requirements for overseas shipments, merely for the supply of our troops, will require the daily receipt at some shipping terminal or terminals of 125 such trains; or, expressed in a different way, one train of 40 cars capacity rolling into some terminal somewhere on the Atlantic seaboard every twelve minutes out of the twenty-four hours, to be unloaded, rehandled aboard ship, and shipped over-

seas. Expressed in terms of shipping, the average transatlantic merchant ship will carry, I believe, somewhere in the vicinity of 6 000 tons. This would mean the daily sending of about 21 such ships out of some port or ports on this side; and, assuming that they required on the average, say, a month for a round trip for loading, making the voyage, docking and unloading, it would necessitate, roughly speaking, the services of about 600 ships constantly plying back and forth from these shores to Europe with supplies merely for maintaining our army on the battle front.



General Perspective, Boston Army Supply Base.

I think you will all appreciate the fact that shipping facilities, as they existed prior to the war, were not sufficient to maintain this service and, in addition, supply the nations allied with us with such necessary food and equipment and other supplies as are demanded. The Government, foreseeing this situation, late last year set to work to lay out a system of army supply bases, so-called, for the purpose of supplying our troops when they were in the field in France; and it is in connection with those supply depots that I am asked to speak to-day.

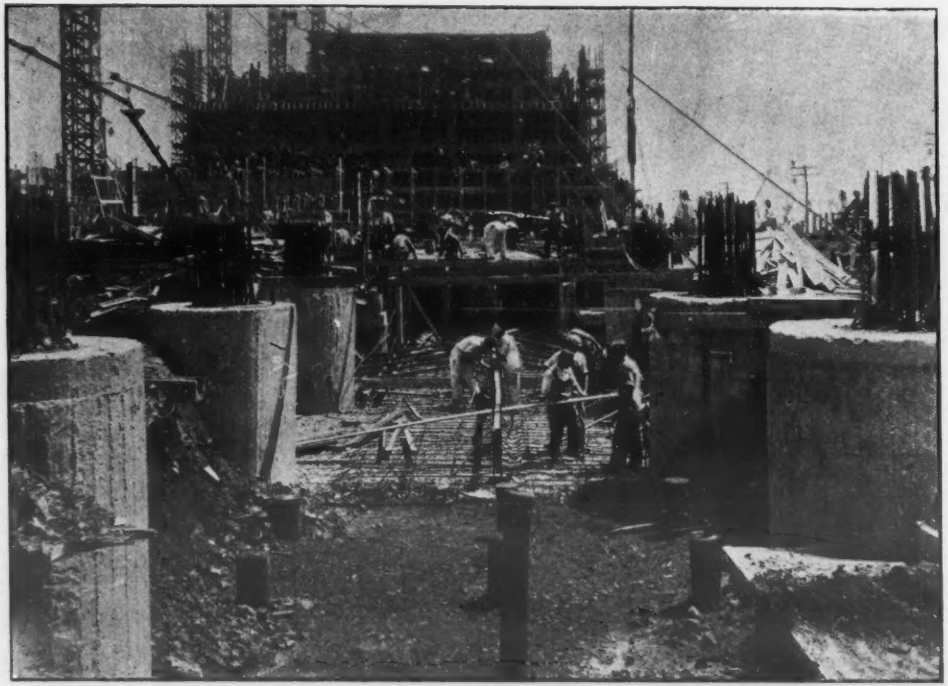
The present program calls for the construction of eight main supply depots, — one at Boston, another at Brooklyn, one at Port Newark, another at Philadelphia, and others at Baltimore,

Norfolk, Charleston, and New Orleans. The Boston terminal will be the second in size, second only to the one at Brooklyn. I believe the estimated cost of the Brooklyn base is thirty-two millions, and of the Boston base twenty-eight millions. Some of these terminals are designed as permanent structures, to serve useful purposes after the war. Others are temporary in character, due to the locality and local needs or the difficulties of construction and the time available for building.

Of course if it were only necessary to receive by freight a definite amount of material and transfer it directly aboard ship that would present a rather simple problem. However, as you will readily see, in handling such vast quantities of material at a constant rate it would be impossible and impracticable to attempt to transfer this freight directly from the car to the ships, because the class of freight received in any given train might not correspond to what was required, and because the arrival of boats is more or less intermittent, and it would require the holding of trains for an undue period. Therefore it becomes necessary to establish a storage depot into which the freight may be transferred from the cars, stored, and reassembled in cargo lots for shipment by boat.

The next essential requirement to adequate storehouses is sufficient terminal facilities for the railroad. The railroad people estimate that there is required, generally speaking, trackage for about four times the number of cars which are expected to be received daily into the terminal; and, therefore, a substantial-sized freight yard is required in connection with any such army base. So we have as the requirements for a given case, first, accessibility by deep water, so that ocean-going vessels may dock; some adequate place for the assembling of cargo, in the nature of a wharf shed; suitable storage or warehouse capacity for holding a sufficient supply of goods so that any cargo may be readily assembled; and a freight yard of sufficient capacity to accommodate the daily arrivals of trains.

In the Boston case the situation seemed to be met by a location in South Boston, adjacent to the so-called Reserve Channel, and immediately southerly from the dry-dock site. At this locality the Government purchased, last winter, a tract of land approximately a mile in length, extending from the L Street bridge, where



CAISSON FOUNDATIONS OF STOREHOUSE.
(Also showing Pipe Tunnel.)

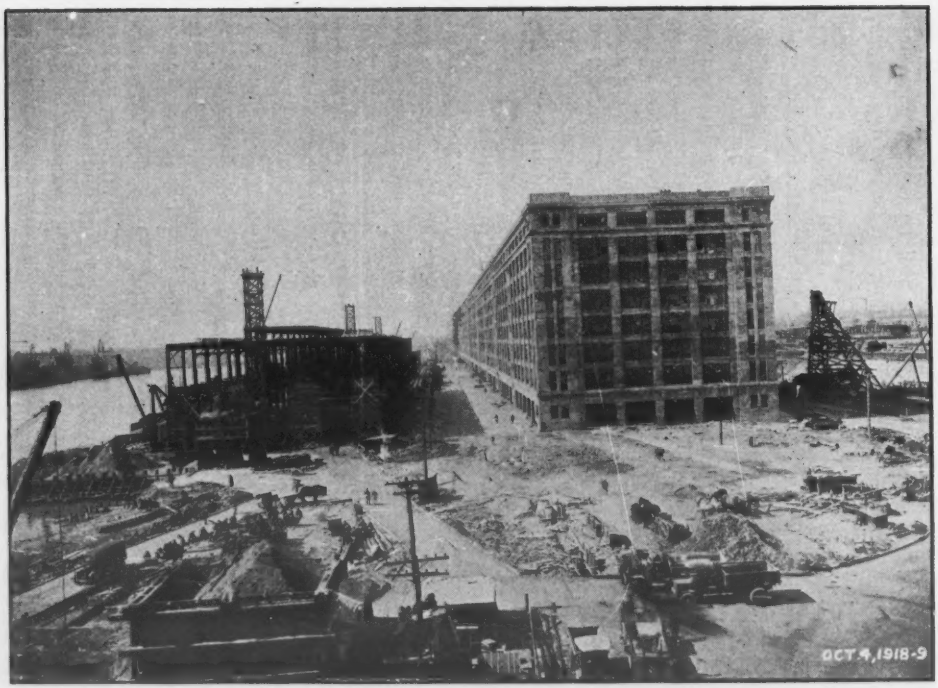
it crosses the Reserve Channel, due easterly to the main ship channel, and containing about fifty acres. On this site we are now erecting the necessary buildings and equipment for operating the base.

The most interesting feature, perhaps, is the storehouse building itself. This base is designed for a daily shipment of 6 000 tons of supplies, — in other words, a capacity of one vessel per day; and that constitutes about five per cent. of the total requirement. If it were not for the terminals existing prior to the war, there would be required twenty such installations built at Boston to take care of the aggregate demand.

To furnish a satisfactory storage medium we are constructing a storehouse building having an aggregate floor area of 1 600 000 sq. ft. This is contained in an eight-story structure, 126 ft. wide and 1 638 ft. long, divided into six independent buildings by means of a separation or fire wall. This building when completed will contain a total of 121 000 cu. yd. of concrete. It is built thoughout with reinforced concrete of the most permanent and substantial type, the floors designed for loads of 300 lb. per square foot and it is equipped with all conveniences, heating, lighting, and elevator service, and designed throughout not only for availability for storage purposes but also for manufacturing purposes after the war. In other words, it is built with the idea of turning it over after the war for purely commercial purposes.

On account of the soil conditions, it was necessary to carry the foundations 55 ft. below the surface of the ground to obtain a satisfactory bearing. The so-called caisson type of foundation was employed, carrying down the cylinder shaft into the ground, belling out on to hardpan at a depth of 55 ft. There were 577 of these caissons required, and the total cost of the caissons alone was a million and a half of dollars.

In spite of the difficulties of foundation construction and the volume of concrete, involving a total of 121 000 cu. yd., this building is approaching completion after a lapse of approximately five months from the time ground was broken. In other words, in five months' time, or by the first of October, the first of the coming month, — I think that is five months and a week, — this building, containing 1 600 000 sq. ft. and 121 000 yd. of concrete, will



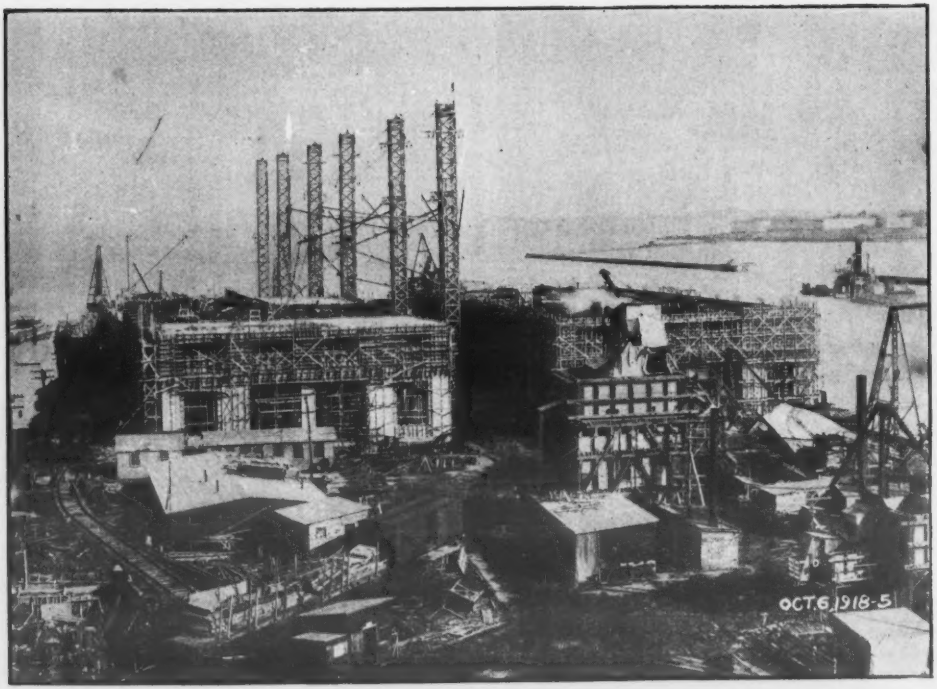
WHARF SHED AND STOREHOUSE.
(1 638 x 100 ft.) (1 638 x 126 ft.)

have been completed, with the exception of some of the equipment. Of course the interior equipment is progressing with the construction of the building, and it will be entirely completed shortly thereafter, so that the building can be put into use as a storehouse at that time.

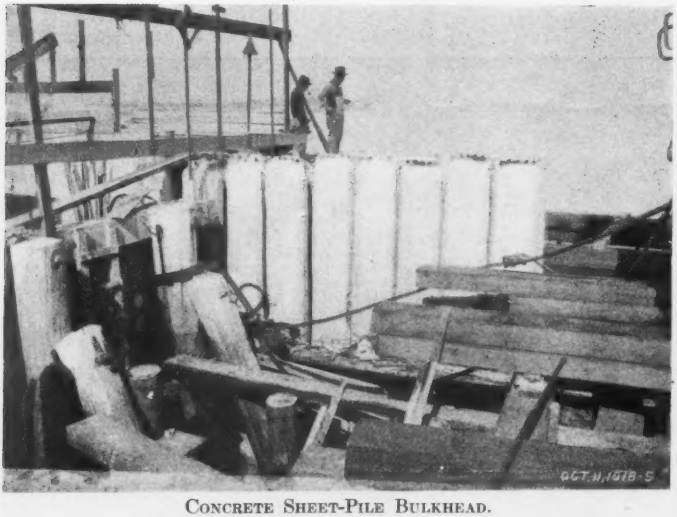
Parallel with the warehouse and separated by an 87-ft. paved roadway, there is another structure, which is known as the " wharf shed." This is the structure into which the cargo will be assembled for loading into ships. It is a two-story building, with a steel superstructure, concrete floors and walls, and is built entirely on wooden piles and a concrete deck. It required for this foundation some 30 000 wooden piles, and approximately 20 000 cu. yd. of concrete on top of the piles. The piling and concreting will be finished by the 25th of this month, and the structural steel, the superstructure, is already being erected. The balance of the work, it is expected, will require only a comparatively short period.

In addition to those two main buildings there is required what is known as a " navy pier shed." If it were not for the magnitude of the main storehouse, this building would itself constitute a very substantial volume of work. The pier shed consists essentially of two parallel buildings, each 924 ft. long and 100 ft. wide, built to a height of three stories. Here again the foundation difficulties made necessary very nearly as much work below ground as above; but this has now been completed and the superstructure work commenced. In connection with this we are driving, I think for the first time in Boston, a concrete sheet-pile bulkhead to retain the flow to either side of the pier. This sheet piling is 42 ft. long and 21 in. thick, and is being driven by means of water jets and extremely heavy driving apparatus.

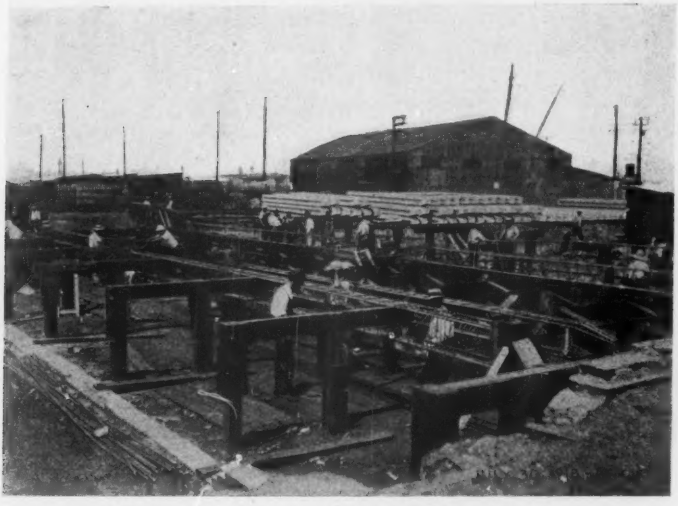
The railroad accommodations call for a total trackage of about 21 miles, of which 11 miles are outside the grounds and 10 miles inside. The freight yard proper is on land belonging to the Commonwealth adjacent to Summer Street and opposite the Commonwealth Fish Pier. There it has been necessary to use practically all the open land as railroad yard to get the necessary accommodation for storage of cars. I believe the capacity of the yard is approximately 750 cars for storage, and the remaining mileage is



NAVAL PIER SHED BUILDINGS.
(Each 924 x 100 ft.)



CONCRETE SHEET-PILE BULKHEAD.



FORMING AND CURING CONCRETE SHEET-PILES.

inside the ground for distribution tracks and for open storage tracks.

The power house, or the house for heating the plant, will take 2 400 h.p. of boilers, and there will be in addition an electric substation and a machine shop.

The administration building, which has only just been designed and finally located, will be four stories in height and 50 by 120 ft., a substantial-sized building.

The number of men we have employed up to date has averaged about 5 500, with a maximum of 7 000. Of course this involves considerable difficulty at the present time, on account of the general scarcity of labor, but at no time has the work been seriously delayed due to lack of sufficient men.

The type of contract which was adopted for this work, and which is generally applied to work done by the Construction Division, such as the building of the several cantonments, the various ordnance plants, and the like, has been the so-called emergency war contract, under which the contractor is reimbursed for all expenses and is paid a fee based upon the cost of the work, but under a sliding scale. That is, the greater the cost of the work the less the rate or percentage which is paid as profit. That is the reason that in this particular case the maximum fee is reached early in the work. The maximum fee allowed under the contract is $250 000. Beyond $250 000 no additional fee can be paid, regardless of the amount of work.

This type of contract has been criticized more or less in some quarters because of misapprehension as to the nature of the fee. The maximum fee of $250 000 is obtained when the volume of work done amounts to $10 000 000. Beyond that, as I have stated, no additional profit is paid. Beginning with an allowance of 7 per cent. up to $100 000, the percentage gradually dwindles until at $10 000 000 the percentage is 2½, which amounts to $250 000, the maximum fee, and beyond that the contractor works for nothing, so far as his profit is concerned. So, in this particular case, the aggregate amount of work being estimated at something like $28 000 000, the contractor will receive considerably less than one per cent., and we anticipate that after he has taken out his overhead expenses, the Government war tax, and made a few

other deductions, he will be fortunate if he has one half of one per cent. on the actual disbursements.

This type of contract, or some modification of it, is almost absolutely necessary, for work of this nature. In this particular case the preparation of the plans and the actual construction work began simultaneously. It would have been actually impossible, without a considerable waste of time, to have prepared plans and drawings in such detail as to permit any contractor to estimate carefully the requirements and the proper costs. Then, again, the changing conditions as to labor and the requirements as to overtime make it impossible to judge with any great degree of accuracy the ultimate cost of the work. For example, we find that a certain portion of the work is holding up some other necessary feature, and so orders are given to work on Sunday, when everybody is paid double time. Or it may be that a certain craft is forced to work, instead of the normal eight hours per day, ten, twelve, or even fourteen hours for a period, in order that its portion of the work shall catch up with the remainder. Under these conditions, of course, no contractor would be able to foresee just what his labor cost might be.

Then, of course, it is inevitable that in a work of this sort, of this magnitude, continual changes must be made. Conditions might arise which would make it desirable to change the form of construction or something, and the result would be that in the end the ordinary form of lump-sum contract would be entirely upset and some sort of an accounting would have to be made. Therefore this form of contract has seemed to work very satisfactorily to the Government and to the contractor. And it leaves the Government in the position where they can select their own contractor, based on his experience and reputation in the community and his general ability for that class of work, and put him at work immediately without the formalities which would be required to be gone through with before executing a lump-sum contract; and, in the main, the experience of the Construction Division has been that this is a decidedly favorable form of contract for this class of work.

The general labor situation, as I mentioned a few moments ago, has given some concern, and the tendency of everybody in

these days to strike when they feel that there is an excessive demand for their services has given us more or less trouble. But in the main I think I ought to say that the attitude of labor, especially of labor leaders, with one or two minor exceptions, has been exceptionally pleasing for its spirit of loyalty and coöperation. Of course where so many men are involved, so many classes, many of them ignorant and entirely without education and without the ability to analyze questions of this sort, some of them are influenced by the occasional agitator, and as a result there have been the usual number of minor labor upsets and troubles which have usually been corrected when the proper parties have been appealed to and the men have been reasoned with.

There has been much criticism about work of this nature, due to the fact that the men individually receive such large sums of money for the work performed. This, however, is due to no fault of the men or of the Government. It is due to the necessities of the case. In order to harmonize and stabilize labor conditions, the Government has seen fit to establish certain standards applying to labor on all Government work which are deemed to be fair to labor and fair to the Government, and one condition was that where a job was done under union conditions the union conditions in the locality should apply, and where work was done under non-union conditions union officials in the neighborhood should not interfere. In this particular case of ours the work is done by a so-called close-shop contractor, employing exclusively union labor; and under the terms of the agreement — the so-called Baker-Gompers Agreement — it is necessary to comply with the prevailing local union conditions as to hours and pay. That means that after eight hours' work all skilled mechanics must be paid double time for all overtime; that the laborers must receive time and a half for overtime; that being the stipulation in the President's proclamation setting aside the eight-hour law as applying on Government work, that, in case more than eight hours was worked, time and a half should be paid for all overtime. Therefore, the rates of pay mount up very rapidly after eight hours, and you can readily appreciate the fact that in attempting to do the great amount of work in the time allotted, namely, eight months, it was absolutely essential to work longer than eight

hours a day. As matter of fact we established at the beginning a ten-hour day, and that very frequently became a twelve- or a fourteen-hour day, — and very often it was seven days a week; with the result that union men on the work, mechanics of one sort and another, are receiving wages from $60 to $70 or $80 or $100, and even up to $110 a week for services rendered. We had one case of an electrician who operated an electrical sub-station, dividing the twenty-four hours with another electrician, and, due to the long hours and the seven-day week I think the night man's pay was $117 a week, which, of course, we felt to be excessive, but nevertheless it is in exact accordance with the requirements of the local union regulations as to pay, and, such being the case, it is unjust to attribute it to the greed of the laborer or to the inefficiency of the contractor. It is one of the unfortunate penalties we have to pay for being in a hurry, having so short a time with so much work to do.

The total project will require, all together, 212 000 cu. yd. of concrete, with over 10 000 tons of reinforcing steel, and the total estimate, as I have said, is $28 000 000; and we were given eight months in which to complete the work. I think you will probably all be interested to know that with the work substantially half completed at this time the present expectations are that the entire project will be completed and turned over for operation well within the time set, and also well within the appropriation allotted for the work. [*Applause.*]

Discussion.

President Davis. It does us all good to find out what the other man is doing, for we are inclined to exaggerate our own difficulties and our own troubles. We don't appreciate how we ought to curtail our own work and limit ourselves in order that the Government's entire program may go through. When we realize the overwhelming amount of work the Government is doing in order to carry on the work on the other side, it makes us the more reconciled, I believe, to getting along with our own difficulties.

I feel quite sure that Major Gow will be willing to answer any questions you may like to ask. There is one question I should

like to ask him, and that is in regard to the 125 000 tons a day. Is there any probability of that decreasing because of salvage operations which may be put into effect on the other side, or does that figure take that into account? We have heard a good deal about the salvage operations, and it seems to me that possibly there might be an initial amount of freight which might not hold in the same ratio after the salvage operations were well organized.

MAJOR GOW. Of course all these figures, Mr. Davis, are approximations, but it is my understanding that the basis of 50 lb. per day per man is what experience has shown to be the requirement. The salvage, of course, undoubtedly will affect the gross requirements; and it will also make a very decided difference whether the troops are actually engaged to a large extent or whether they are only intermittently on the firing line. But this is taken as the average requirement on which to base the capacity of the several shipping plants.

MR. J. M. DIVEN. Is the estimate of 600 ships, 21 ships sailing per day, based on 2 000 000 men?

MAJOR GOW. No; that was decided on as the ultimate capacity, about 125 000 tons, for 5 000 000 men.

EXPERIENCE IN LABOR TROUBLES.

Topical Discussion.

[*September 12, 1918.*]

The President. I have found that a pension system has been one of the most remarkable stabilizers of the labor force, and has served to retain a large part of an organization that would otherwise have been tempted by outside employment through higher wages and have been lost to the city water works.

We have in Philadelphia a pension system carried on by contributions, which is available to any man who has been twenty years in the employ of the city and who has reached the age of sixty years. The maximum amount of the pension is $1 200 and from that goes down to a minimum of, I think, 50 per cent. of what the man has received during the last five years of his active service with the city. I think it is no exaggeration to say that hundreds of our employees would have left us to take up outside employment at a very much higher rate of wages if it had not been for the hope of benefiting by that pension. Of course that is intimately connected with the fact that this is an old man's age at home, and the fact that the older men are less attracted, probably, by the opportunities for moving, — perhaps they do not care to go through the very arduous work and harder conditions that go with the munitions, shipbuilding work, and so forth. The pension system has proved its worth in holding and stabilizing the force at this particular time if for no other reason. You know Eve was the source of all our troubles; and while I do not like to blame it on the women, yet I have found that the women really have always been a large factor in tending to have men take outside employment, giving up a steady job for the sake of getting larger wages. I have had hundreds of men come to me and say, " My next-door neighbor is working at Cramp's," — or over at Hog Island, or at the New York Shipbuilding Company, or Baldwin's, or some place like that,— " and he is coming home

with $25, $30 or $40 a week, and his wife comes in and tells my wife about it, and my wife simply can't stand it. Here I am getting perhaps, $18 or $20 a week, and my neighbor is getting double that, and, while I want to stay with the water works, and don't want to lose the job, yet the pressure is too strong at home." That is only human nature; but it is an interesting thought that really pride and vanity have had a tendency to offset things.

I heard an interesting thing in connection with the Bethlehem Steel Works, showing, perhaps, on the opposite side from what it would be in the municipal plant. In the Bethlehem they are paying tremendously high wages. A man can get all he wants to live on in three or four days' work a week, and there is no incentive to work the other days in the week. The families are satisfied, because all the people in the town are working under the same conditions, and there is no rivalry. Yet the Bethlehem executives have gone out of their way to get the employees in debt and get them to buy pianos, victrolas, and so forth, so as to compel them to work six days a week in order to pay the debt. That is a very curious thing, but it is an actual fact. I suppose all of us have found — although we do not pay the extremely high wages that the Bethlehem people pay, — yet even with the wages that are paid to-day by the water works — that a good many men will not work over five days a week, because they have enough to live on. Formerly a man had to work six days a week in order to make a living; now he can make enough in five days and doesn't have to work the sixth. That is the case with the unmarried man who has not the household inclinations.

Another instance that that brings to my mind is this: We have the vicious practice of paying for Saturday afternoons whether the man works or not. I don't know whether that prevails in most of the companies, but I believe the Saturday half holiday paid for is an exceedingly bad practice, because it tends to create a large amount of absenteeism. We try to get over that by not permitting any man to work at all on Saturday unless he has worked the five preceding days.

MR. J. M. DIVEN. How is that pension fund created?

THE PRESIDENT. By contributions. It has been running only about five years at the present time. It was started on supposedly

the best statistics, and up to the present time it has been self-supporting.

MR. DIVEN. Contributions from the men?

THE PRESIDENT. Yes.

MR. DIVEN. Like contributory insurance?

THE PRESIDENT. Yes. It is compulsory with salaried employees and it is optional on the part of the per diem employees. But practically all the per diem employees have participated, and up to the present time the fund has been self-supporting.

MR. FRANK L. FULLER. That is taken out of their weekly envelope?

THE PRESIDENT. Yes.

A MEMBER. What is the minimum term of service?

THE PRESIDENT. It has been, twenty years in the city's service, and the man must reach the age of sixty years before he can participate in the pension, unless he has actually served twenty years before he is sixty years old and has been incapacitated through no fault of his own. Then, on a certificate from three doctors, he can participate in the pension fund. For instance, a man might be fifty-six years of age and have contributed or have been in the employ of the city for twenty years, and contributed the requisite number of years in the pension fund. If he happened to have an accident and was not fit for continued employment, he could be put on the pension fund, on the certificates from three physicians that he was incapacitated.

A MEMBER. What happens to the man who is discharged or who resigns before he is eligible to the pension, and who has contributed to the fund? Is his money returned to him?

THE PRESIDENT. He can withdraw. I remember we discharged one man for theft who was over sixty years of age and was eligible for the pension, but we could not prevent him from participating in the fund even though we discharged him for theft which was proven. That was one of the oversights when the Act was drawn up which I think will have to be corrected in the future.

MR. C. A. BINGHAM.* I came here more to listen, but to start discussion I would like to state some troubles we are having at the

* City Manager, Waltham, Mass.

present time, and it will possibly bring out some discussion. We have a hundred employees in our various departments. They are unionized. At the present time they have been on strike three weeks. We have 30 men working in the departments, 60 men out, 10 on the fence. We pay a minimum of $3 for an eight-hour day. We have 38 men at $3, 29 at $3.25, 23 at $3.50, and the balance at $4 or more. This is for an eight-hour day, but we give Saturday afternoon with pay for five months during the summer. That Saturday afternoon spread over the year is equivalent to 3.8% additional pay. We give two weeks' vacation with full pay to any man who has worked over two hundred eighty days. That is equal to 4.2% a year. If a man has worked twenty-five years and has become incapacitated and is over sixty years of age, the city pensions him. If he has worked twenty-five years and is sixty-five years old he can receive a pension whether he is incapacitated or not; or if incapacitated from employment, after fifteen years, regardless of age. That pension comes entirely from the public funds. We have figured from the dozen pensions we now have and from other statistics that after a man has been in the service for twenty-five years the average term of his pension runs for eight years, and it equals 8.6 per cent. of his pay during the twenty-five years. That is a total of 16.6 per cent. which the city gives the city employee over the private plant in giving those privileges. In other words, it is exactly one sixth, so that a man who is receiving $3 from the city gets the equivalent of $3.50 in a private plant. In addition to that, the work is continuous, winter and summer, for these permanent men.

They have now gone out on strike, and their contention is that the minimum shall be $3.25, and all the men now graded as skilled laborers, mechanics and so forth, shall receive also 25 cents additional. That means $25 a day, or $7 500 a year, which we have not included in our budget.

During the three weeks we have found out some very interesting things. In the Street Department, ash and refuse division, they used to have two or three trucks cleaning up the city, but for the last two weeks have only had one truck doing exactly the same work that two or three trucks did before. On the present truck we have a foreman, mechanics, and blacksmiths, working

for from $4 to $6 a day; but of course that one truck does not equal the cost of three trucks formerly, and we are getting more per dollar in work out of one truck than we did out of three. The same occurs in the other departments.

The bad part comes here: We can take back 30 of the 60, and, of course, will take the best men, the $3.25 or the $3.50 men, and the older men nearing the pensions; but when we refuse to take back the $3 men they will all say they have been discriminated against because they were instrumental in the strike and in the operation of the Union. That is true. The $3 men are the men who have been in the department a very few months, and they are the ones who started the labor agitation and have convinced the older men that they belong to a secret organization and should strike for the benefit of the other men. But the old men are holding the strike for the reason that the older men cannot go out and get other jobs like the newcomers who are going into munition plants and so forth, and making big money. We are having conferences every day, and personally I don't know how the matter will work out. But I thought possibly the information might lead to some discussion which would help us all eventually.

MR. H. V. MACKSEY. In the city of Woburn, which almost adjoins Waltham, we have similar conditions. In the summer we have 100 to 125 men on the pay-roll, but during the winter, when there is practically no work being done, we have 20 or 25. We have within the last three years increased the minimum wage from $2 to $3. We have practically the same conditions that

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NOTE. On September 14 the above strike was settled by the execution of an agreement drawn up by the Chamber of Commerce Arbitration Committee and submitted to both sides.

Clause 1. Minimum to be raised to $3.25.

Clause 2. Agreement to hold no more strikes during the war.

Clause 3. All employees now receiving $3.25 or more are not to request any increase.

Clause 4. No back dating on the increase of clause 1.

Clause 5. Striking employees to be re-engaged only as work and funds permit.

Clause 6. All future differences to be settled by the city manager, arbitrator of City Employees' Union, and a third mutually selected member.

they have in Waltham in regard to holidays. We pay for legal holidays; we pay for Saturday afternoons four months during the summer, and we give two weeks' vacation with pay to every man who has worked two hundred days during the year.

Three years ago a union was established in Woburn, to which I had no objection. I believe that the workingman is justified in having a union, and that if a union is controlled and guided by intelligent, honest men it will do no damage to the workingman or to his employer. Unfortunately, the average laborers who constitute a union are uneducated, and they are led by the man with the fluent tongue. He is not always the most intelligent, nor is he always the most honest member. In Woburn, we have now reached a point where we have trouble, not a strike, but our men have abandoned us, because we will not give them a minimum wage of $3.50. It is my opinion that it is partly bad management on our part which has caused this condition. Any man who understood laboring men and labor conditions should have known that during 1918 we could not hope in this part of the country to hold ordinary good labor at less than $3 a day. Our laborers very early in the year asked for $3, and our mayor refused to approve the rate. The men were forced to threaten strike, and then they got the three dollars. During that time the strike bug got into their systems, and some of them were disappointed because there was no strike. As soon as possible they seized upon another matter, in order to go before the mayor, and incidentally they demanded $3.50, which demand he refused. Knowing the prevailing rate of wages, and knowing the conditions under which the workingmen live, I advised that the proper thing to do was to give them $3.50, because we have a certain amount of work which we want done at this time, and we have money enough to pay for it. Our money will not pay for as much work for us as we had hoped to do, but the non-essential work could be postponed.

I look upon the municipal employee as a different man from the man who is employed by a private concern. The men who work under me have lived many years in Woburn; I have been there but few. They will probably live there all their lives; — I sincerely hope that I shall not be buried in Woburn. When

talking with them, one must remember that he is talking with his neighbors, that he is talking with his friends, that he is talking with men who are as deeply interested in the success of the municipal enterprise and in the improvement of their city as he is. One must remember that in the municipal corporation each one of them has the voting power of one share of stock, — no more and no less. All these things are to be considered.

I am far from being a politician, — I was not built on that line, and could not be one if I tried; and yet I believe that any employee of a city, county, town, state, or of the Federal Government, who blinds himself to the fact that politics is one great factor in his job, is foolish. We should recognize politics; we should do business with the politician on a friendly basis as long as he is square and as long as he is on the level. I believe that true politics, proper politics as a man in my position should play it, is what the people of the city, the people who hire me and who pay me, wish me to play.

If we took a popular vote in our city to-day, the great majority of the people — not only the working people but the merchants who have the workingman's trade, the landlord who collects the rent from him, and even the manufacturers who own the tanneries and the chemical works in Woburn — would say, "Sure, you must pay that rate; you might as well pay it; they are the men you have had for years, and they are the men you are to have in years to come, and you cannot import labor to fill their places; make the best terms you can with them to-day, give them a living wage." Very few men to-day who are earning $18 to $25 a week are buying baby grands, victrolas, or tin Lizzies; they are satisfied if there is corned beef and cabbage on the table on the days that the Food Administration says that beef may be eaten. We should not be carried away by the idea that they are merely wage earners, and take the capitalistic view that it is our sole business to get as much out of them as we can. We should consider them as men; as a matter of business, it pays to do so. Almost every big manufacturer will agree that he should have a welfare department. We all should consider the fact that a satisfied workingman is an asset to any employer, and a dissatisfied workingman is a liability. My men working at $3.50 are

worth much more than they would be if forced to accept $3.25 or $3. You cannot hold a man's nose to the grindstone all the time. You can say, "There is your job," and put him on it, and if he does a good day's work, and is energetic and willing, you get a satisfactory result and you are pleased. If he is an absolute loafer or mutineer, you discharge him; but if he just soldiers along and does a fair day's work, but takes no interest, you get a poor job, an expensive job, but you can't discharge the man.

When you come to consider what you should do, you must recognize the fundamental union principle, "All for one, and one for all." That principle should be accepted by the employer as well as the employee. When we place the minimum rate at $3.50, we know full well that we will have a certain number of men who are not worth $3.50, and we will have a certain other number of men who are worth, perhaps, $4.50. But the strong must carry the weak, and the young men must carry the old; that is their part of the contract, as well as ours. If, in all municipal employments, we try to classify laborers as to age and as to physical ability, not only will we be in trouble all the time, arguing with the men that this man should not go up, and that that man should come down, but we will feel uncomfortable when we look into the face of the old workingman, who has been in the service many years, and spent the best part of his life on the job, and say to him, "Mike, I am sorry, but I must cut a quarter off your rate to-day; you are not much good now." The citizens who are paying the bills do not want us to do that. It is not good business. There is such a thing as being fair, — coldly fair, absolutely just, — and you can deal in that way with machinery; give it the right amount of oil and the right amount of power, stop it when you like, start it when you like, and it goes. Feed a dog, and he will always keep at your heel and call you master; but a man will not act that way. Let us not forget that we are dealing with men; let us not forget that there is a condition in this world to-day such as no man living ever saw, and that probably no man living will ever see its like again. The workingman to-day has his chance to fight for wages and win, and if he goes too far and is unreasonable he will pay the penalty later. When this war is over and all our men come back, conditions will be

recast, and the common laboring man will unfortunately be forced again to take off his hat and say to the wealthy man, "Please let me earn a dollar." I think we make a mistake if now we fight too hard for low-priced labor. We make the mistake, if our men walk away from us to get employment elsewhere, if we think they are influenced by German propaganda. They are not. They are influenced by the fact that their neighbors go out and do better, and they cannot understand why they should sit idly by and suffer. When it is all over they will not be praised for staying on the job. If your child is dressed better than my child to-day, you and I will say, "Oh, that is a mere trifle"; but the mothers do not think it a trifle, and you can't make them think that it is. But if your child and my child are not well fed to-day, you and I demand a change, — and demand it now, — and you say, "I am going to feed my child as well as any other man feeds his; I am going to clothe him as well as any other man clothes his; I am going to educate him as well as any other man educates his." It is that ambition in the American citizen that has made the American citizen what he is, — that has given him more courage for fighting and more ability to fight than any other man in the field.

We can't win the war nor make this a great country by singing the "Star-Spangled Banner" at nine o'clock on any given evening. We can only win this war, or any other war, by treating men as men all the time. Do not be carried away by the fact that dollars and appropriations are the things we are dealing in. If we can't handle the man who is over us, as well as the men who work under us, we are failing in our jobs. I realize that I am just now among the failures. I have put myself in that class, because I am not able to handle the man who is over me. I am forced to be helpless, without men, to-day — because I have not got head enough, I have not the ability, to convince the man who is to-day mayor of the city that he should change his attitude, and let us put our city in proper, peaceful working order.

Mr. Agnew.* I have a very small system and very few men, but unfortunately the Government built a plant in my town and robbed me of all my men, unless I paid about double the wages I

* Superintendent Water Works, Scituate, Mass.

had been in the habit of paying. Mr. Moore spoke on the subject of raising rates. My works is one of those where we had to raise the rates. Where we used to pay the ordinary workingman $2.50 a day, we are now paying $4 and $4.25 for ordinary labor. We have to do it. They did not ask us for it, but we raised our wages to compare with the wages which were being paid on the Government cantonment. We have had no trouble, but submitted to the inevitable and gracefully paid the wages before our men left.

Mr. J. M. Diven.* Most municipal plants work on a budget system, and with rapidly changing prices, both for material and labor, it keeps one in a constant worry to keep within budget appropriations made more than a year in advance. It has been possible to take care of the labor advances by cutting down the force in the speaker's case, and cutting out all work not absolutely necessary. Good laborers have been able, however, to secure much higher wages than the city could afford to pay, both on government work and from contractors doing state and other work on the cost plus system, where their costs were not limited by fixed appropriations. This has made it hard to keep first-class laborers, though some of the men realized that with the city they had a permanent job, year in and year out, rain or shine, and that the other positions would be more or less temporary, so they have stayed on at considerably less pay than they could have secured in other positions.

Mr. A. E. Martin.† I want to heartily endorse every word of our friend, Mr. Macksey — every word. At the same time, here is a little condition which makes you feel a little bit as though human nature were on the opposite side once in a while. Our men walked out, — practically every man with the exception, perhaps, of three or four who were stand-bys and who had been with us for years and could not walk out — they were getting fairly good pay. We had four men left on the job where we were laying 10-in. and 8-in. water pipe, tying in side streets as we went along. And the men left. They gave us no reason, but the next morning, we heard indirectly, would come back to us for $3.50 a

* Superintendent Water Works, Troy, N. Y.
† Superintendent Water Works, Springfield, Mass.

day. The board would not listen to it, and said it could not do anything without consulting the other departments of the city. I was on the point of going on a vacation, and asked, "Shall I go or stay? Do you want to handle this yourselves, or shall I stay and help handle it?" They answered, "Go ahead." I went away and came back two weeks later; found the work at a standstill and the newspapers were slamming the Water Department. This was a new street and nobody could get in ahead of us. I went to the board the next morning and asked what they were going to do. They then voted to raise the wages to $3.50, or $3.52 — we were paying $3.28 in Springfield, and we voted to give the men $3.52, 24 cents a day more. We sent word to the men that we were ready to give them this and word came back the next morning, "We will come back to work for $4 a day; we must not lose our vacation" — which they had of course lost by leaving; "we must have a rest period of fifteen minutes twice a day, and we must have full time, wet or dry." I wonder how Mr. Macksey feels about that.

MR. MACKSEY. Not language which could be put in public print.

MR. MARTIN. Well, the men did not come back, because I had no authority to give them any more money. So we hired a contractor to come in with a few men — 12 or 15 — to help us out. We had men enough to do our pipe laying but we couldn't do the digging too. So these men came in with a foreman, who, as I heard somebody remark, might have been of some use once, but his day of usefulness had gone by. He sat on the job and saw the men attempt to work. No, I won't say that they *attempted* to work — played at work. And, out of 10 or 15 men, perhaps one third of them would work while the rest were leaning on their shovels and looking at the job. We paid the contractor $3.50 a day and paid him a 15 per cent. bonus, which made the rate of wages $4.02 for those men, and we finally got the job finished and got out of it. And I thank my lucky stars it was finished before this meeting occurred, so that I could come down to it. But that little incident of human nature (I call it pure cussedness) got me going, and I haven't recovered yet. Those fellows would have come back the next day for $3.50, but after loafing two weeks intended to make up the loss of $4.00.

MR. FRANK J. GIFFORD. We have not heard from Mr. Gear. He informs me that word has just come from Holyoke that a strike has been called in his department since he left.

THE PRESIDENT. What are you going to do?

MR. PATRICK GEAR. Settle.

THE PRESIDENT. Pay them what they want?

MR. GEAR. Sure. I received the Springfield *Republican* this morning, saying that a strike had been called since I left. I will settle that to-morrow morning when I get home.

I have been interested in all the papers I have heard since I came to this meeting. The train I am going on is the 5.52, and if I get started talking I might miss it, and you might all say, before I got through, what the lady said when she was at Nantasket Beach and had been in the water. As she was coming out she said, "I am so glad I am near my clothes." [*Laughter.*]

The labor troubles in Holyoke are just the same as everywhere else. I have quite a force of men working with me, and we get along very nicely. The old fellows did not strike. It is a new gang of laborers that has made the trouble. The other men would not let go, no matter what they would ask.

With all the papers that were read here, any superintendent could stand up on the floor and take a half hour at least to express his feelings on what he had heard. I am glad that the Sedgwick paper is to be printed and sent to us, and I will have one of our Holyoke papers print it. It was the best I have ever heard. There is not any question, of course, that we will win this war. We have got the biggest man in the world to-day in this country — everybody listens when he speaks; and, as a darky boy down South said to his chum — he was in uniform and the chum was not, and the chum said, "I don't want to go" — the boy in uniform said, "You haven't got no chance for escape; if President Wilson wants you he will get you; a man that can take an hour of daylight away from Almighty God and give it to the people, and a man who can take the railroads away from the men that owned them and give them to his son-in-law — what chance have you to get away?" [*Laughter.*] I would like to know what chance the Kaiser has to get away from that kind of a man. The American boys have the world with them.

There is no question that we have to give laborers to-day what they ask if we want them. Some people may think that they are unreasonable; but when you see what we have to pay for our dinner here in Boston, and our supper, and when we go home and think that we have as nice a meal at home from our wife, that is just as good as that, and how does she do it on the small pay we give her — when you take these things into account, the laboring man does not seem so unreasonable. It is not any use for municipal corporations to think that they can hire men for the same as they did two years ago. The only thing that is keeping the men, as the last speaker said, is that there is a pension going to them when they are old, and when the war is over things might be a little better than they are now, and the work would not be so plentiful in the outside factories. There are lots of people who will disagree with us there; they think there has got to be good business in the coming years. They think we will have to build up the foreign countries; and if we do, we might as well make up our minds that we will have to meet a continued labor shortage for some years to come.

JAMES BURNIE.

James Burnie, superintendent of the Biddeford and Saco Water Company, and one of the best known and most active members of the New England Water Works Association, passed away at his home in Biddeford, on November 27. The cause of his death was anemia, which had been in evidence for some time, but had not become serious until the early part of last summer, at which time his condition became so serious as to compel him to abandon the active conduct of his office. Until then, he had attended regularly to his business, but in July turned over the management of the company's business to his son, assistant superintendent Arthur N. Burnie.

The passing of James Burnie is a great loss to Biddeford, where he had for years been one of the most prominent figures, being very public spirited, and taking an active interest in all matters pertaining to the welfare of the city.

He was a generous but unostentatious giver to charity.

James Burnie possessed one of the strongest and most admirable characters of his day; honest in the highest sense, and with an intense dislike for sham.

He was a great lover and strong believer in American institutions, and a thorough patriot.

James Burnie was of Scotch descent, being born in Stranraer, Scotland, June 17, 1842, and was a son of James and Jannette Burnie.

He came to Ridgeway, Canada, with his parents, while a boy, where he remained until the outbreak of the Civil War, when he enlisted in Detroit as a private in the 17th Regiment of Regulars, serving until the close of the war, and was discharged with one of the most honorable records of his regiment. He took part in many prominent engagements, among which were Chancellorsville and Gettysburg, being severely wounded at Gettysburg, and for three or four days lay on the ground without care, helpless.

Upon being discharged from the service, he located in Portland, where he learned the trade of a machinist, after which he served

as marine engineer on coastwise steamers. From this time, he was connected with testing steam-driven vessels.

He then entered the employ of the Portland Water Company, under the late George P. Westcott, and was active in the reconstruction, placing upon a substantial basis the Sebago Lake supply of the Portland Company.

In 1884, he went to Biddeford as superintendent of the Biddeford and Saco Water Company, the plant being then in the process of construction, and covering but a small territory. At the present time the company has a total of forty-five hundred subscribers and covers Saco, Old Orchard, Pine Point, and along the coast, the plant having reached a high state of development under the efficient management of Mr. Burnie.

Mr. Burnie was interested in several fraternal organizations, being a member of the Ancient Landmark Lodge and Mount Vernon Chapter, Royal Arch, A. F. and A. M., of Portland; and Bradford Commandery, K. T., of Biddeford. He was a 32d degree Mason, holding membership in a Scottish rites body in Portland. He was a member of one of the Portland lodges of Odd Fellows, of Mavoshem Lodge, K. P., of Biddeford, and the 17th Regiment Association.

Mr. Burnie was one of the most companionable of men, and made friends with whomever he came in contact.

He was twice married, and is survived by a widow and three children: James W. Burnie, of Plattsmouth, Neb.; Miss Helen M. Burnie, of Biddeford, by his first marriage; and Arthur N. Burnie, superintendent of the Biddeford and Saco Water Company, by his second marriage.

Mr. Burnie became a member of the New England Water Works Association June 11, 1890, and has been one of its most active and popular members. He was Vice-President in 1901, 1902, 1905, and 1915.

The Association, in common with his home city and state, experiences a great loss with the passing away of Mr. Burnie, which will be felt by all, both old and young, who have had the pleasure of his acquaintance.

PROCEEDINGS.

November Meeting.

Hotel Brunswick,
Boston, November 14, 1918.

Vice-President Samuel E. Killam presiding.
The following members and guests were present:

Honorary Members.

E. C. Brooks.
R. C. P. Coggeshall.
Desmond FitzGerald.
R. J. Thomas. — 4.

Members.

L. M. Bancroft.
G. W. Batchelder.
A. E. Blackmer.
G. A. Carpenter.
F. L. Cole.
John Cullen.
A. O. Doane.
John Doyle.
L. R. Dunn.
E. D. Eldredge.
F. L. Fuller.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
J. A. Gould.
R. A. Hale.
A. R. Hathaway.
J. L. Howard.
W. F. Howland.
J. A. Hoy.
Willard Kent.
S. E. Killam.
G. A. King.
P. J. Lucey.
H. V. Macksey.
A. E. Martin.
H. A. Miller.
M. L. Miller.
H. E. Perry.
L. C. Robinson.
G. A. Sampson.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
D. N. Tower.
F. B. Wilkins.
I. S. Wood.
M. B. Wright. — 38.

Associates.

Bond, Harold L., Co., F. M. Bates.
Builders Iron Foundry, A. B. Coulters.
Byers, A. M., Co., H. F. Fiske.
Edison Mfg. Co., H. L. B. Watson.
Hayes Pump Machinery Co., F. H. Hayes.
Hersey Mfg. Co., W. A. Hersey.
Lead Lined Iron Pipe Co., T. E. Dwyer.
Ludlow Valve Mfg. Co., A. R. Taylor.
Mueller, H., Mfg. Co., C. J. G. Haas.
National Meter Co., J. G. Lufkin and H. L. Weston.
Neptune Meter Co., H. H. Kinsey.
Rensselaer Valve Co., C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Thomson Meter Company, E. M. Shedd.
Union Water Meter Co., D. K. Otis and H. W. Jacobs.

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United Brass Mfg. Co., G. A. Caldwell.
Warren Foundry & Machine Co., J. H. Morrison.
Water Works Equipment Co., W. H. Van Winkle.
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GUESTS.

MASSACHUSETTS.

East Pepperell, Lewis D. Bemis.
Worcester, Robert F. Batchelder.

RHODE ISLAND.

Bristol, J. M. Jones.

PENNSYLVANIA.

Pittsburgh, George F. Maglott. — 4.

The Secretary read the following names of applicants for membership, approved and recommended by the Executive Committee:

Clarence W. Mills, Woonsocket, R. I., superintendent Woonsocket Water Department; Harold S. Noyes, Newburyport, Mass., secretary and treasurer, Water Commissioners; John P. Young, Worcester, Mass., foreman Water Department; Henry T. Wheelock, Lynn, Mass., foreman Lynn Water Department.

On motion of Mr. Macksey, the Secretary was authorized to cast one ballot in favor of the applicants, and he having so voted they were declared duly elected members of the Association.

VICE-PRESIDENT KILLAM. I want to take this opportunity of calling upon one of our esteemed past presidents, a member of the Engineers of National Defense, who has recently taken a trip to the New York water supply. We realize that many things have taken place in the last few days. We know what we have passed through, and little did we think at our September meeting that changes would happen so rapidly as they have. Only time can tell just what will happen in the future, but we will look on the bright side and hope that everything will be for the best, and that our boys who have gone across will soon be back on their native soil, where they will be doubly welcome. I now take pleasure in calling upon Desmond FitzGerald. [*Applause.*]

Remarks by Mr. Desmond FitzGerald.

Mr. FitzGerald. It is always a pleasure and a privilege to talk to this Association, and as I look around and see so many familiar faces I am quite assured that you will pardon any imperfections in this little talk I am to give you, which must be extemporaneous and with very few minutes' notice. I don't know that it will interest you, but I know mighty well that I was interested as perhaps I had not been for a long time before in a little trip I took last June with Mr. Stearns over the sources of the New York water supply, the new Catskill supply; and when I was asked if I wouldn't say a word here this afternoon, I thought perhaps that might interest you.

You all know that the New York supply is the biggest in the world in many respects, — the largest in the country, certainly, and almost the longest in extent of works, although the Los Angeles works, I fancy, is somewhat longer. Mr. Stearns and I left here on the eight o'clock train in the morning and changed cars at Chatham — I speak of this because it is a mighty good way to go if any of you ever wish to go; we changed cars at Chatham and then at Hudson, and then we crossed the Hudson River and landed at Kingston Point and got up to the hotel in time for supper that night.

Kingston is right at the foot of the mountains, and there at once you are surrounded with the beautiful purple mists and masses of the mountains. Kingston itself is quite an interesting place. It was the seat of the old New York senate. We passed our leisure time in examining the town and going into the cemetery, seeing some of the old graves, and going into the old senate house. It did seem very interesting to go into that little bit of a house, not much larger than a gate-house, which was the original senate chamber of what is now the great Empire State of New York.

In the meantime Mr. Waldo Smith, the chief engineer of the works, was on his way from New York, and reached Kingston that evening. The next morning early we took his car, a small Franklin, and he was the chauffeur, — and a good one, too, — and went around the Ashokan Reservoirs. They are extremely

interesting. Of course we have in Massachusetts some of the finest reservoirs in the world, but these at Ashokan were interesting because they were not entirely of the same type, and we always have the varieties and variations. There are two principal reservoirs, and around those reservoirs I think is about the finest road I ever saw for a water supply. It wasn't wide but it was very smooth, as smooth as a floor; and we had no trouble in going at the rate of thirty-five miles an hour. That was thought to be slow, but I don't care to go very rapidly myself, — I like to see things; so, out of consideration for an old man, they reduced the speed to thirty-five miles an hour.

We went around the reservoirs and saw the beautiful situation there at the foot of the Catskill Mountains, and then came to the gate-house. Before going into the gate-house we went up on to an eminence and climbed a tower by one of these circular iron stairways, and the views from there were most beautiful. Then we came down to the gate-houses. The gate-houses are very remarkable. I don't think I have ever seen gate-houses anywhere in the world on such a large scale, with such enormous gates, and with so much machinery so well adapted to handle every part of them. There is a laboratory there, but you know we have laboratories on our own works so there was perhaps nothing very remarkable about that to a Boston engineer. The interesting specialty there was the wonderful fountain. I don't expect ever to see another fountain anywhere in the world like it. Really it makes you stand aghast to see the whole water supply of the city of New York coming out through little two-inch nozzles and carried up into the air perhaps thirty or forty feet in jets which are close together and yet you can identify them. The water was so white that these jets were like a tablecloth, perfectly white, and you can imagine that it is a beautiful sight. The water which is stored in reservoirs where the bottoms have not been properly prepared, under our old Boston system, as a rule gives out a good deal of sulphureted hydrogen for the first few years, and I have a number of times stood at the outlets when they were drawing the water when it was very disagreeable indeed to stay there. If there should have been some organic matter left, which I think there w[illegible] – I don't think the preparation of the bottom

of the reservoirs for the New York supply was done in the same way in which our Boston reservoirs have been treated, — the idea of this aëration was, of course, to get rid of any gases which might be in the water when they were drawing it from the bottom. But I did not detect any odor, and the water was perfectly white. The water which comes out from the bottom of a large and deep reservoir which has not been well prepared is very apt to be partly discolored and to contain foul gases, but I didn't notice any there.

Then we got into another terrible machine. If the first one was a brute, this was a monster. It was an eight-passenger car, and I said to myself, This means forty or forty-five miles an hour; and it did. But they kept the speed down to thirty-five miles an hour out of regard for me, I think, most of the way, but we did go occasionally forty-two miles an hour; I know, because I saw the indicator. But I made up my mind to enjoy it; that if I was going to be smashed up I might just as well have a good time as be all the time wondering what was going to happen. [*Laughter.*] And we did have a good time. We went the full length of the aqueduct. We made the crossing of the Hudson at Newburg, and there we saw the very beautiful gate-house. I don't think I have ever seen a gate-house anywhere in the world like it. I have seen larger ones, but those at the Ashokan Reservoirs are very artistic gate-houses on a very large scale and built of stone, — I think some parts, as I remember, were artificial stone; but this gate-house on the Hudson, which receives the tunnel after passing down under the river — and you know that is quite a remarkable crossing and I will say a word as to it later — is one of the most beautiful and artistic buildings I have ever seen. It stands there fronting the Hudson River.

Inside of the gate-house — well, I kept out because I didn't want to be asked to go down one thousand feet; but there was a machine which was suspended in the air and which some men did go down in for one thousand feet. I didn't care to go, and we didn't have time even if we had had the inclination. This crossing of the Hudson — you look at the river and, we will say, it is a mile wide, — I don't know exactly how wide it is at that point, — and say it is thirty or forty feet deep. Then you have the silt and the clay and the sand and the gravel which filled up

the old bed of the river which was made by the glaciers. When they undertook to make the borings from the surface of the river they couldn't get satisfactory results, so they had to sink shafts on each side of the river and then run hand-drill borings through the rock. The thing was, of course, to find out how deep this old bed was. It was many hundreds of feet deep, carved out by the old glaciers and filled up with glacial débris. I don't recall the exact depth they had to go, but it was something like eight or nine hundred feet, I think, below the river, in order to get into good, solid rock.

Then following down the Hudson we came to the terminal, or equalizing reservoir. That is a perfectly superb structure. The dam there I think is one of the most remarkable I have ever seen, — the Kensico Dam. There has been a greater effort to produce an artistic effect than even at the Ashokan Reservoirs, and it looks to me as if the architect had had an unlimited order. I never have seen anywhere in the world more elaborate — well, I won't call them " elaborate " because they are sufficiently simple, but extensive — decorations. As you stand on the Kensico Dam and look down the stream, I should think, for a distance of half a mile, you see an open, level space in which there is a very extensive fountain arrangement and grounds; and the dam itself is flanked by structures which are built, I think, so as to add to its dignity. That reservoir in itself, although it is a compensating reservoir for the aqueduct, would be a very large storage reservoir anywhere in the world.

Then we went on down to the terminal reservoir, where the pipes extend into tunnels and pass under the East River to New York; and the rest of the system then is by an enormous tunnel, as you know, through the bed rock under the city of New York and feeding the different parts of the city from that as from a main, and then over to Brooklyn and Staten Island.

We had allowed one day for this visit, and they had guaranteed to deposit us at the Grand Central Station by six o'clock, and they did. But in order to do it we had to go through the streets of New York at a rate of speed, — well, I won't attempt to say what it was, but my heart was in my mouth every moment. [*Laughter.*] I don't know that I have given you much idea of our trip, but if

you have enjoyed the talk as much as I have, or a tenth part as much as I enjoyed the trip, I shall be more than satisfied. Thank you very much. [*Applause.*]

VICE-PRESIDENT KILLAM. As you all know, Mr. FitzGerald is one of the fathers of our Boston additional supply. Some twenty years ago, when I first became connected with the Metropolitan Works, one of the first books I picked up on entering the engineering force was a small book in the front of which Mr. FitzGerald had written, "A dangerous book for young engineers to use." [*Laughter.*] I was telling him to-day that I had never used that book. At another time, when I was relieving Mr. Sherman, who was Mr. FitzGerald's assistant at that time, I recall one afternoon while I was figuring out some measurements Mr. FitzGerald arose suddenly and came over to where I was and said, "Say, young man, what are you doing?" I said, "I am figuring" — I didn't know what he was going to do to me. He said, "Why don't you make a noise?" [*Laughter.*] It was so still in the room I think he supposed I wasn't there.

When I was first connected with the works the engineer under whom I was employed was a man who had for his motto, "Do it now." At that time he was doing it, and he has been doing it ever since. He is a hard-working engineer, always thinking out something new, and it was a great pleasure to be associated with him in connection with the Metropolitan Works. I learned a great deal from him at that time, and he has been very good to me ever since in forwarding information of various kinds. He has prepared, and after a good deal of work I have finally succeeded in getting him to present, a paper to this Association, which he will now read to you. I refer to Caleb Mills Saville, of Hartford, Conn. [*Applause.*]

Mr. Caleb M. Saville, chief engineer, Board of Water Commissioners, Hartford, Conn., then read a paper entitled, "Rates of Flow in Service Pipes and Meters." Mr. Lewis R. Dunn, superintendent of the Winthrop Water Department, told of the successful use of water meters in Winthrop.

The subject for topical discussion was, "Experience in Labor Troubles." No one desiring to say anything on the subject, the meeting adjourned.

EXECUTIVE COMMITTEE

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, November 13, 1918, at eleven o'clock A.M.

Present: Samuel E. Killam, Henry V. Macksey, Percy R. Sanders, Frank J. Gifford, Lewis M. Bancroft, and Willard Kent.

Four applications for membership were received and unanimously recommended therefor, viz.: Harold S. Noyes, secretary and treasurer Water Commissioners, Newburyport, Mass.; Henry T. Wheelock, foreman, Lynn Water Department, Lynn, Mass.; Clarence W. Mills, superintendent Water Works, Woonsocket, R. I. and John P. Young, foreman, Water Department, Worcester, Mass.

The Secretary was instructed to communicate with associate members in regard to listing their representatives at the meetings of the Association.

Adjourned.

Attest, WILLARD KENT, *Secretary.*

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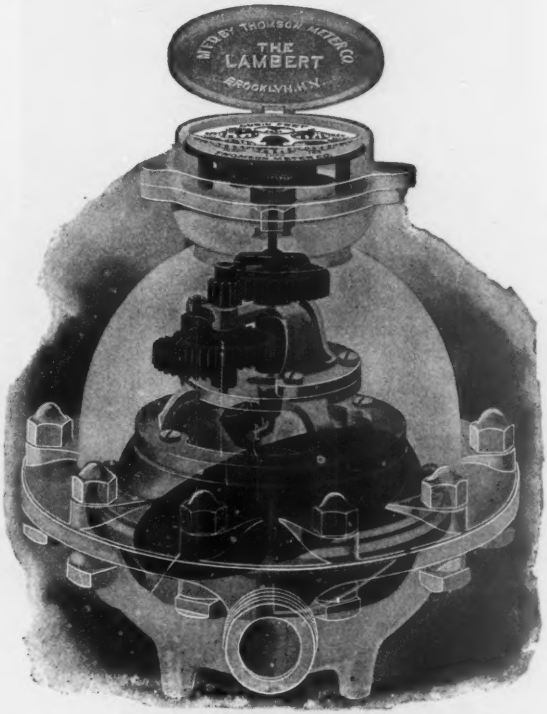

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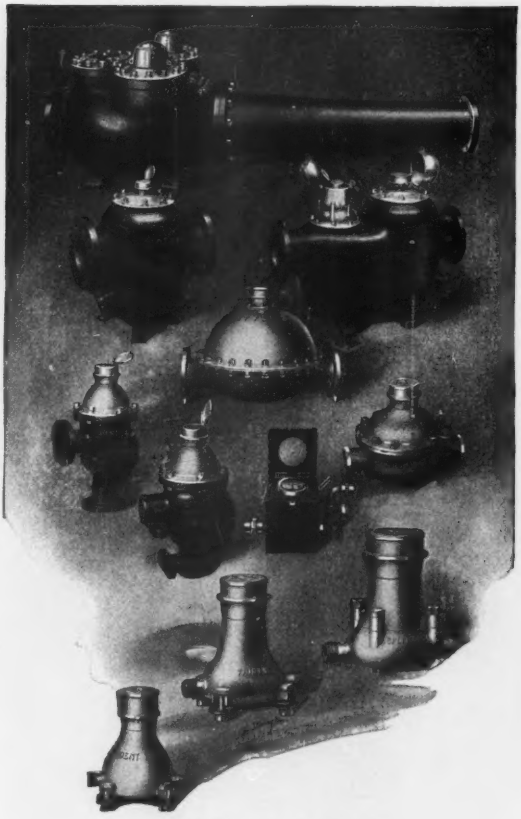

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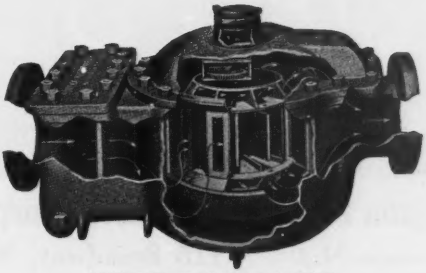

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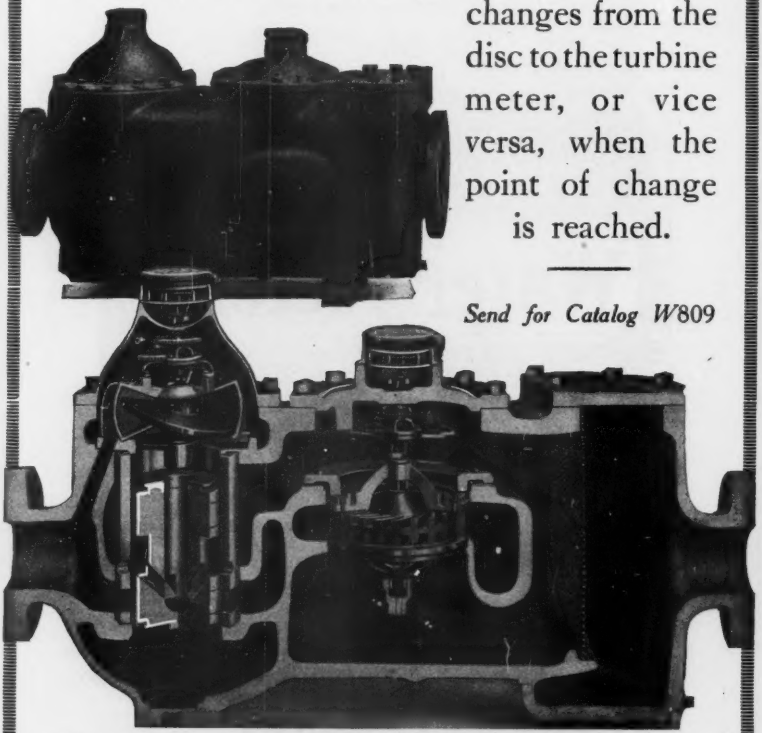
Compound Meter

The design of this meter is such that the action of the plunger valve (both up and down) is always sharp and positive; "no breaking point" in the registration where the flow changes from the disc to the turbine meter, or vice versa, when the point of change is reached.

Send for Catalog W809



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Works: Harrison, N. J. **115 Broadway, New York**

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WATER METERS

AMERICAN NIAGARA

ACCESSIBLE

Our meter may be opened at the bolted flange without disconnecting it from the pipe, each intermediate gear may then be lifted from its bearing and the measuring chamber removed from its seat. No other meter is so simple and accessible for inspection, cleaning or repairing. Sample meter sent to any water works on trial.

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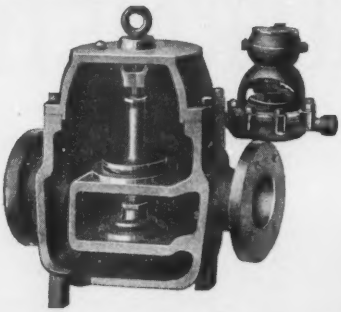

Union Compounding Valve

IN 7 WEEKS

THROUGH INCREASED REVENUE

GENTLEMEN: June 4, 1918.

In reply to your request for figures on test of 4-inch Union Compounding Valve installed at the plant of the ..... in this city, we submit the result as stated below:

Apr. 15, '18.	4 in. Current meter read	9,255,000 cu. ft.
May 15, '18.	4 in. „ „ „	9,788,700 „ „
		533,700 „ „
	1-in. King by-pass meter read	132.600 „ „
	Total . . .	666,300 „ „
	Average consumption on 2 prior months	572,600 „ „
	Actual increased registration	93,700 „ „

The increased registration at our rates netted us for one month the sum of $74.96 and the cost of the valve being $121.50.

As a result of this test we have purchased the valve installed and have also ordered another.

Yours respectfully,

(. . . . .) Supt. Water Works

Facsimile of this letter complete and Catalogue NE-49 on request

UNION WATER METER CO.

INCORPORATED 1868

WORCESTER, MASS.

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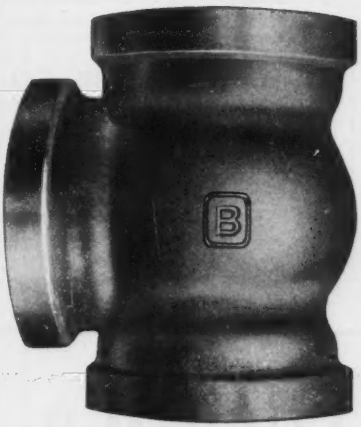

are used to advantage by many water works in New England. Their resistance to bursting stresses is great. We stock a large number of Bells and Tees, and make a specialty of odd-shaped castings. Our latest **Catalogue "L"** is yours for the asking.

The VENTURI METER

is quick to detect pump slippage. The new Type W instrument (illustrated in cut) will give you a continuous record as to the condition of your pump valves, and as to the actual efficiency of your pumps.

Ask for **Bulletin 84 W**

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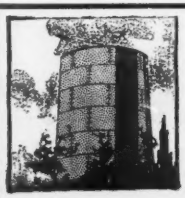

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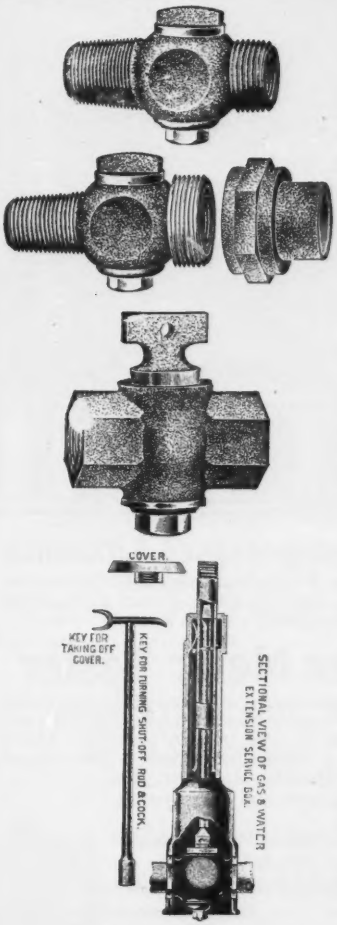

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Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

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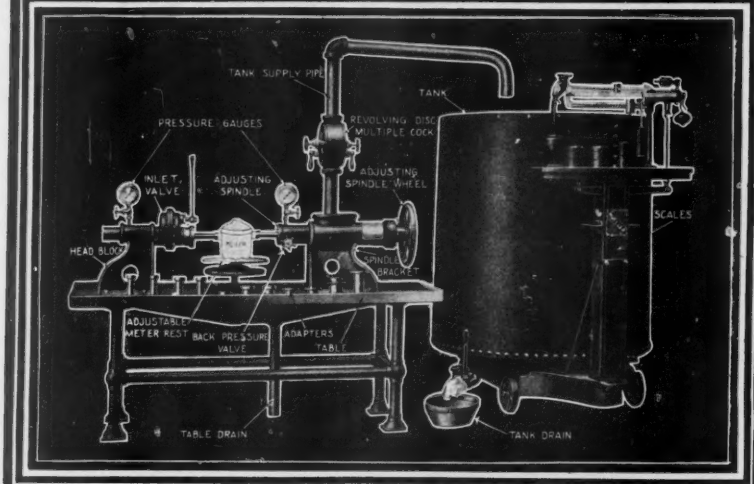

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The Mueller will prove exactly what each meter does—will enable you to adjust each meter to absolute accuracy—will save more than its cost year after year. Used and endorsed by leading municipalities. The name Mueller guarantees both Quality and Service.

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Our **Feed-Water Filter** will keep oil out of your boiler.

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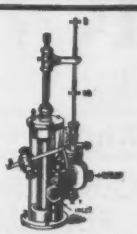

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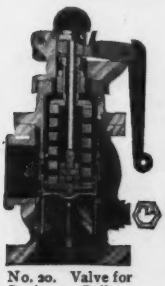

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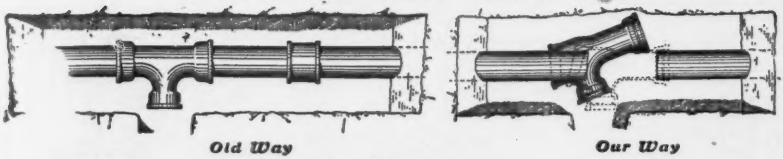

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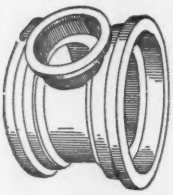

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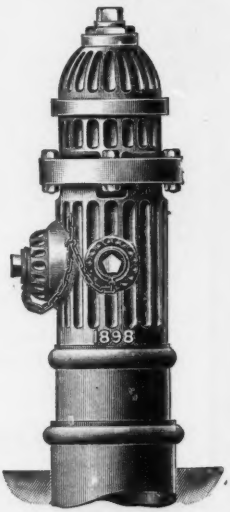

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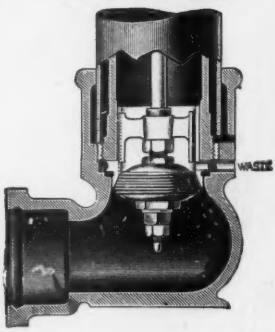
A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



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DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
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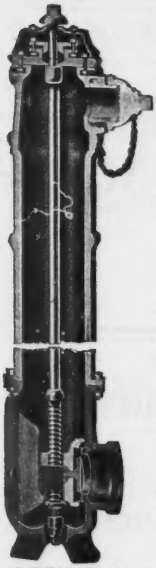

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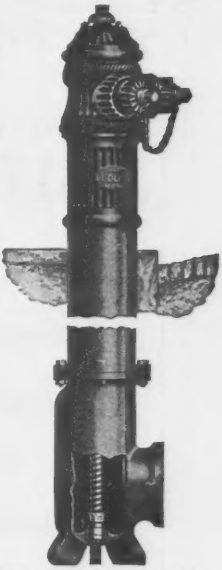
This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



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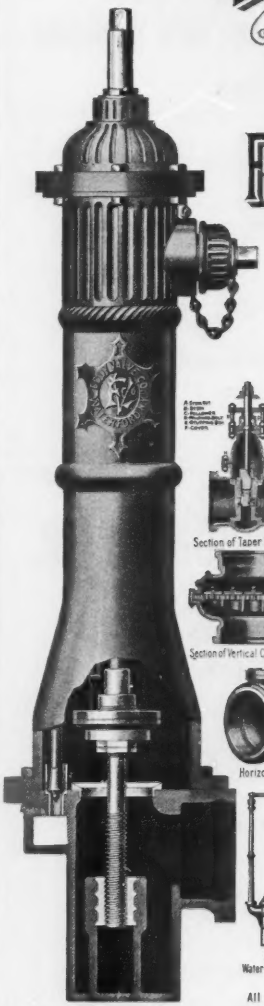
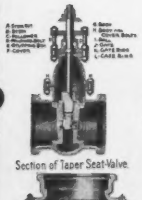
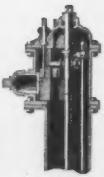
EDDY FIRE HYDRANT



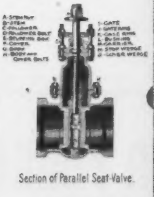
VALVE OPEN – DRIP CLOSED.



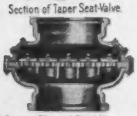
Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cut-off.



Section of Parallel Seat-Valve.



Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

Horizontal Check-Valve.

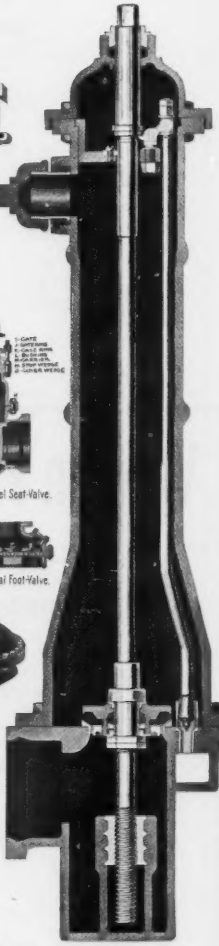
Vertical Foot-Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.

All Goods made by the EDDY VALVE COMPANY are manufactured exclusively at WATERFORD, N.Y., U.S.A.



VALVE CLOSED – DRIP OPEN.

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Such is the latest story of Cast-Iron Pipe efficiency — and the efficiency of the good, old-fashioned bell-and-spigot joint.

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For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable, but dangerous — **LEAD WOOL** may be employed to advantage. It makes perfectly tight joints to withstand the highest pressures, yet sufficiently elastic to admit of considerable sagging or settling of the pipe without causing the joint to leak. The difference in this respect, as compared with the poured joint, is notable.

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Highest quality Lead Lined Iron Pipe and Fittings

***Also* Pure Block-Tin Lined Iron Pipe and Fittings**

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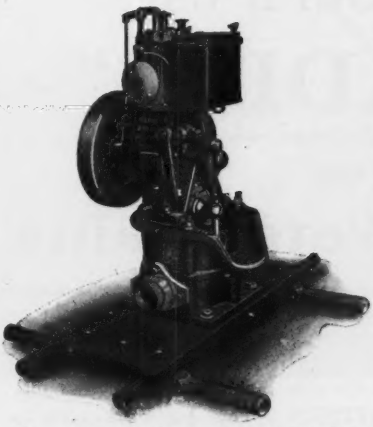

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Can be attached to any Diaphragm Pump

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Now in use by many of the Water Departments.

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Twelve Reasons Why

YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

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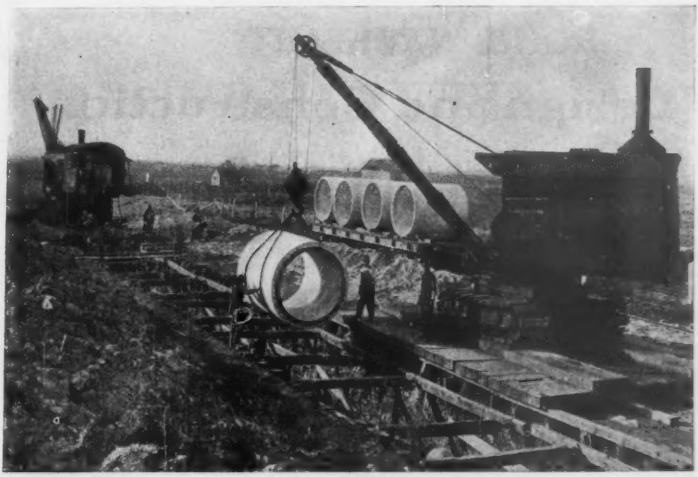
LAND TITLE BUILDING PHILADELPHIA



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New England Water Works Association,

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at.....

.....*being desirous of admission into the New England Water Works Association, hereby make application for* .....

(resident, non-resident or associate)

.....*membership.*

I am.....*years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed,.....

Address,.....

Dated,.....*191*

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Entrance fee is $5.00 for resident and $3.00 for non-resident members.
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